# JOURNAL

OF THE

# ROYAL MICROSCOPICAL SOCIETY;

## CONTAINING ITS TRANSACTIONS AND PROCEEDINGS,

AND A SUMMARY OF CURRENT RESEARCHES RELATING TO

ZOOLOGY AND BOTANY

(principally Invertebrata and Cryptogamia),

MICROSCOPY, &c.



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*Edited by*

**FRANK CRISP, LL.B., B.A.,**

*One of the Secretaries of the Society*
*and a Vice-President and Treasurer of the Linnean Society of London;*

WITH THE ASSISTANCE OF THE PUBLICATION COMMITTEE AND

A. W. BENNETT, M.A., B.Sc.,
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*Professor of Comparative Anatomy in King's College,*

S. O. RIDLEY, M.A., *of the British Museum*, AND JOHN MAYALL, JUN.,
FELLOWS OF THE SOCIETY.

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Ser. 2.—Vol. I. Part 4.
(AUGUST.)

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THIS Journal is published bi-monthly, on the second Wednesday of the months of February, April, June, August, October, and December. It varies in size, according to convenience, but does not contain less than 8 sheets (128 pp.) with Plates and Woodcuts as required. The price to non-Fellows is 4*s.* per Number.

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(2.) SUMMARY of CURRENT RESEARCHES relating to ZOOLOGY and BOTANY (principally Invertebrata and Cryptogamia, with the Embryology and Histology of the higher Animals and Plants), and MICROSCOPY (properly so called): being abstracts of or extracts from the more important of the articles contained in the various British and Foreign Journals, Transactions, &c., from time to time added to the Library, so far as they relate to the above subjects.

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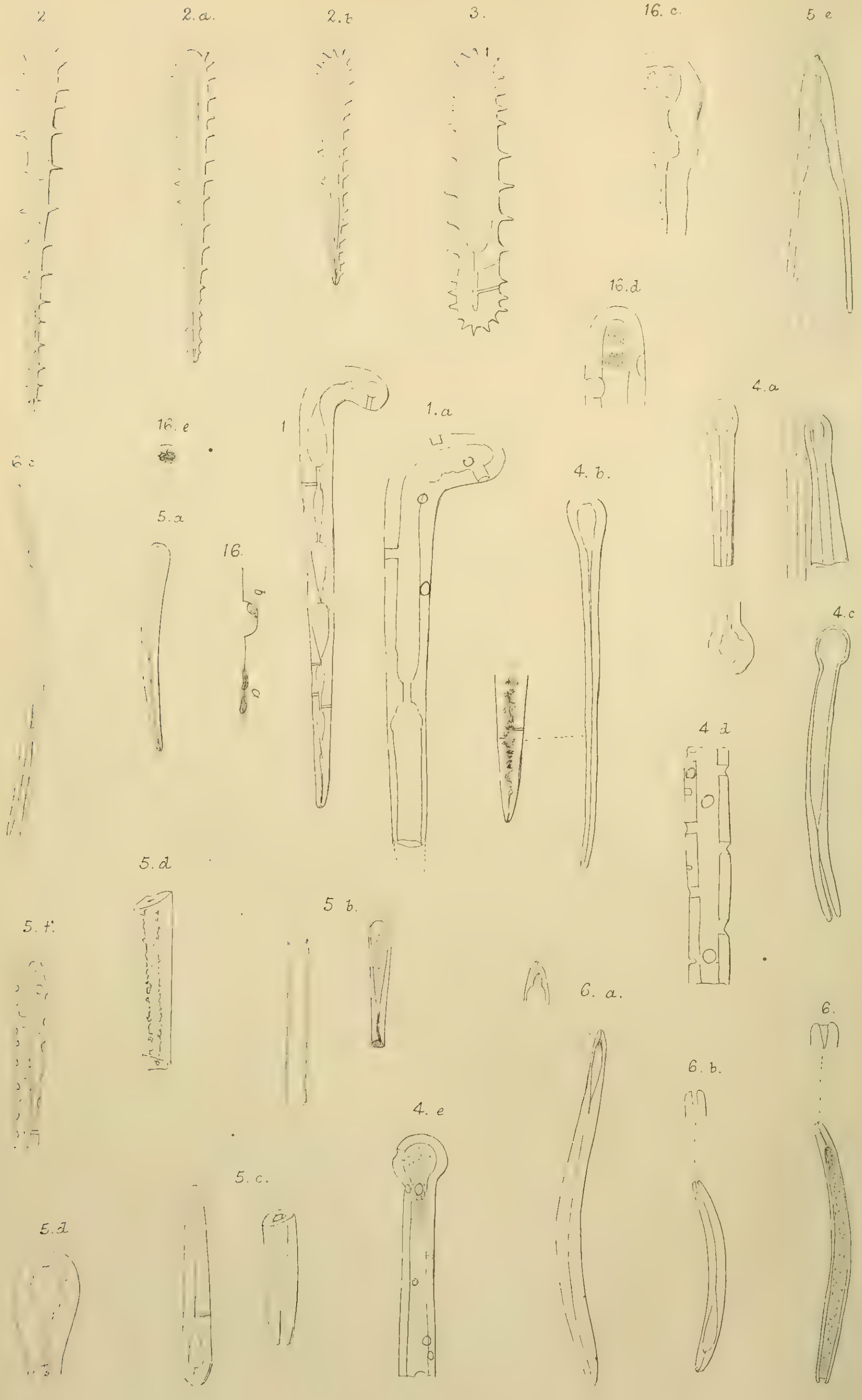


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Sponge Spicules.

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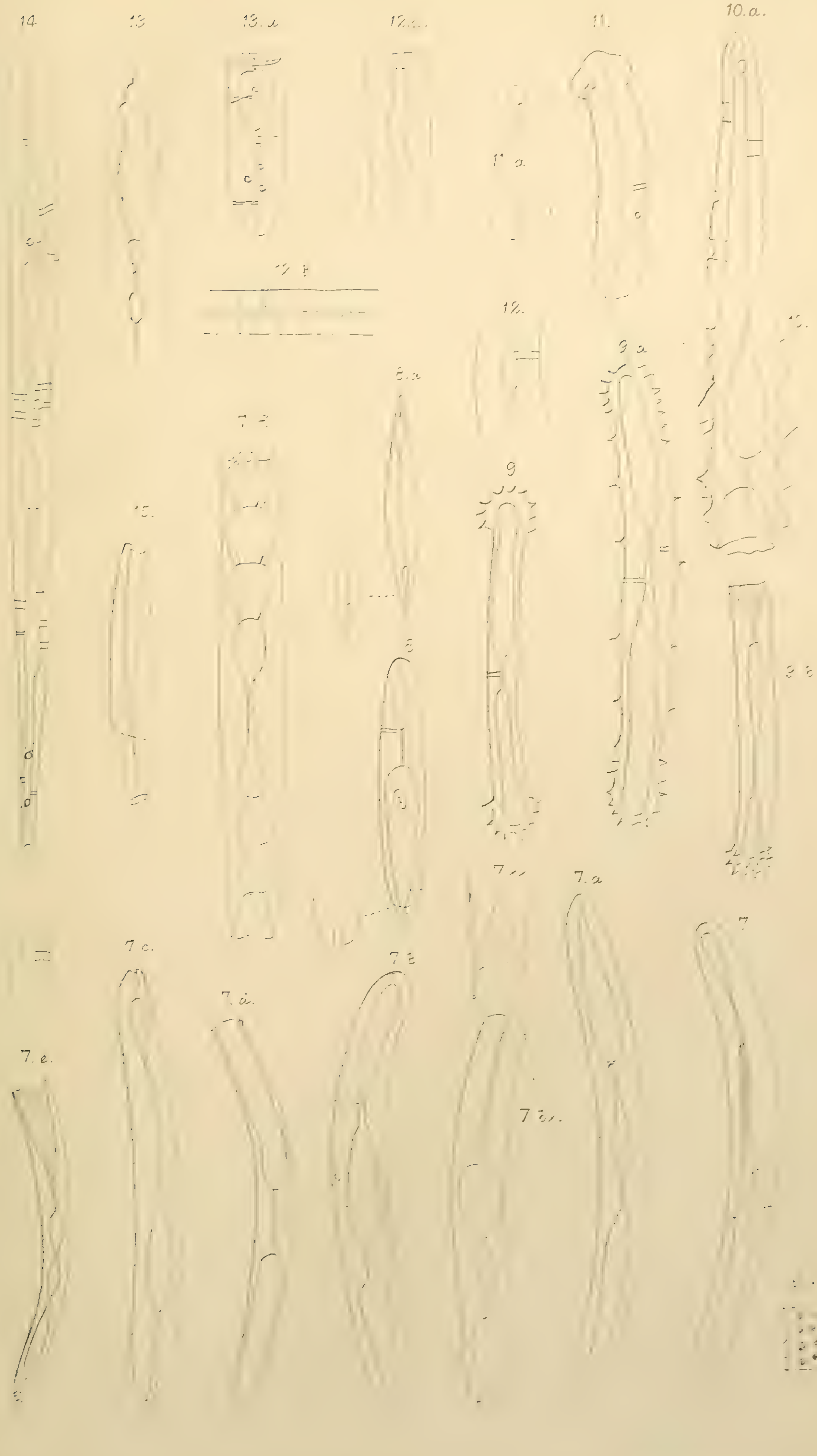


Sponge Spicules

F. M. D. del.

# JOURNAL

OF THE

# ROYAL MICROSCOPICAL SOCIETY.

AUGUST 1881.


## TRANSACTIONS OF THE SOCIETY.

### IX.—*On some Remarkable Enlargements of the Axial Canals of Sponge Spicules and their Causes.* By Professor P. Martin Duncan, M.B., F.R.S., Pres. R.M.S., Professor of Geology and Mineralogy in King's College, London.

(*Read 9th June*, 1881.)

Plates VII. and VIII.

It is well known that the spicules of siliceous Spongida may or may not contain narrow axial tubular canals, visible under moderately high powers of the Microscope.

In many instances the canal resembles the capillary tube of a thermometer in shape; and it may be rounded, pointed, or

EXPLANATION OF PLATES VII. AND VIII.

Fig. 1.—An acuate, basally rectangulated spicule, with enlargements and perforations.
" 1*a*.—Another, enlargements great, penetrations.
" 2.—Acuate, verticillately spined, open at the end, and with several enlargements.
" 2*a*.—With one enlargement.
" 2*b*.— " " differing in shape.
" 3.—Cylindrical, entirely spined, with two perforations, a short normal canal, and a conoid enlargement.
" 4*a*.—Spinulates, one is normal, the others have enlargements more or less irregular, of the axial and bulb canal.
" 4*b*.—Spinulate attenuate with axial canal, large in bulb, and rotten looking at end.
" 4*c*.—Curved spinulate with great bulbous enlargement and one near the open axial canal at the end.
" 4*d*.—Penetrations in a piece of a spinulate.
" 4*e*.—Spinulate with perforations and rugged axial canal-sides.
" 5*a*.—Attenuate acuate bent, enlargements simple.
" 5*b*.—Greatly enlarged canals.
" 5*c*.—Open axial canals and enlargements.
" 5*d*.—Bulb and stem, ragged enlargements.
" 5*e*.—Thinning, fracture, and gradual narrowing of the axial tube to where it becomes open. [Fig. 5*f*.

even slightly inflated at the end or ends, according to the shape of the enclosing spicule. But in some spicules there is no trace of a canal in the axis, whilst in compound or branching ones, the axial tube, still retaining its delicate appearance, may be as complicated in its direction as the environing siliceous structure. The

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FIG. 5*f*.—Circular depressions crowding a spicule which has broken where penetration has occurred, axial tube slightly enlarged.
" 6.—An acerate with a great enlargement of the axial canal, and an eroded appearance of the walls of it.
" 6*a*.—With a symmetrical enlargement at one end, elsewhere normal.
" 6*b*.—With a greater enlargement.
" 6*c*.—A long acerate, open at both ends, with simple swellings.
" 6**.—Eroded surface of one of the spicula.
" 7.—Fusiformi-cylindrical, bent more at the ends than in the middle, blunt-pointed spicula. Spicule showing two enlargements and much normal axial canal, whose extremities are closed; many penetrations.
" 7*a*.—Same shaped spicule, differently enlarged axial canal.
" 7*b*.—Same shape; penetrations and enlargements.
" 7*b**.—Differently shaped enlargements.
" 7*c*.—Open axial canal, which is enlarged in two places considerably, and universally slightly.
" 7*d*.—Great and regular enlargement of two parts of the axial canal, with fracture at the ends.
" 7*e*.—Fracture from thinning, and granular appearance on the wall of the canal.
" 7*f*.—Moniliform enlargements, and fracture at both ends.
" 7**.—An eroded axial canal wall.
" 8.—Fusiformi-cylindrical spicule, open at the ends and penetrated; axial canal enlarged in two places.
" 8*a*.—A spicule with open axial canal, and solution has taken place of the point of one. The enlargements are slight, and of the nature noticed by Carter.
" 9.—A cylindrical and basally spined spicule with greatly enlarged axial canal full of air except centrally where it is normal and has a penetration.
" 9*a*.—An entirely spined spicule, with one perfect perforation and greatly enlarged canal.
" 9*b*.—Fracture from thinning.
" 10.—A large entirely spined spicule, fractured along a line of thinning of a great expansion.
" 10*a*.—Penetrations into an axial canal, which is enlarged; depressions on the surface of the spicule.
" 11.—Short, stout, curved spiculate, with normal axial canal and three incomplete perforations.
" 11*a*.—Open axial canal, and bulb part of another specimen; canal enlarged.
" 12.—A penetration into a canal, enlargement close by.
" 12*a*.—Eroded axial canal.
" 12*b*.—Normal canal, penetrations incomplete.
" 13.—Remarkably shaped axial canal.
" 13*a*.—Penetrations, fracture, and enlargements.
" 14.—A very long acuate, showing penetrations and enlargements, the axial canal being open.
" 15.—Erosion on the surface of the spicule, besides enlargement of the axial canal.
" 16*a*.—Zoospore-shaped-body, free in a concave depression with circular outline.

Hexactinellids frequently present a minute spicule in their larger spicules, or a canal may exist.

All the axial canals which have been described hitherto are represented as extremely small tubes, which in some spinulate spicula have a bulbous enlargement extremely narrow in its dimensions. In some instances, general tubular enlargement of the canal has been observed to occur, especially in young specimens, and also as the result of internal decay.*

On the occasion of the last Conversazione of this Society, on April 20th, 1881, I had the pleasure of exhibiting several kinds of sponge spicula which, with perfect external configuration, possessed an internal series of elongate, conoidal swellings of the axial canal. The variations in the size and number of these enlargements were shown to be numerous, and they added greatly to the beauty of the transparent siliceous spicula which contained them. A careful examination of the subject has led me to bring it before you again, as it possesses much interest to the microscopist, and relates to the manner in which organic silica is dissolved in the deep sea.

The specimens in one slide were given to me many months since by Dr. Stolterfoth, of Chester, and they came from the greatest known depth of the Pacific, in the neighbourhood of Japan. Subsequently Dr. Stolterfoth kindly lent me six other slides from the same locality.

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FIG. 16*b*.—Two cells on the spicule, occupying the position of circular concave depressions.

„ 16*c*.—A bulbous enlargement on a spinulate spicule. Distinct granules in a minutely granular matrix, faintly tinted green.

„ 16*d*.—Granules greenish, arranged in separate masses in the end of a dilated axial canal.

„ 16*e*.—The upper view of *b*, closely resembling the zoospore of *Achlya penetrans* Dunc.

*Measurements.*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| FIG. | 1.—Length | $\frac{1}{100}$ | inch; | breadth, | greatest, | $\frac{1}{1000}$ | inch. |
| „ | 2. „ | $\frac{1}{200}$ | „ | „ | „ | $\frac{1}{1200}$ | „ |
| „ | 3. „ | $\frac{1}{300}$ | „ | „ | „ | $\frac{1}{1100}$ | „ |
| „ | 4*a*. | .. | | „ | | $\frac{1}{1000}$ to $\frac{1}{2000}$ | „ |
| „ | 5. | .. | | „ | „ | $\frac{1}{1000}$ | „ |
| „ | 5*b*. | .. | | „ | „ | $\frac{1}{1300}$ | „ |
| „ | 6. „ | $\frac{1}{33}$ | „ | „ | „ | $\frac{1}{1300}$ | „ |
| „ | {6*a*. 6*b*.} „ | $\frac{1}{100}$ | „ | „ | „ | $\frac{1}{1300}$ | „ |
| „ | 7. „ | $\frac{1}{60}$ | „ | „ | „ | $\frac{1}{1000}$ | „ |
| „ | 7*a*. „ | $\frac{1}{100}$ | „ | „ | „ | $\frac{1}{1100}$ | „ |
| „ | 8. | .. | | „ | „ | $\frac{1}{1000}$ | „ |
| „ | 9. „ | $\frac{1}{100}$ | „ | „ | „ | $\frac{1}{1200}$ | „ |
| „ | 10. | .. | | „ | „ | $\frac{1}{1000}$ | „ |

„ 16. Diameter of penetration, $\frac{1}{7200}$ inch.

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* See *infra*, p. 566.

*Description of the Spicula.*

One of the most striking examples of the symmetrical enlargements of parts of an axial canal, is seen in a well-preserved spicula of the "acuate, basally rectangulated" type of Bowerbank (Fig. 1). The spicule is $\frac{1}{100}$ inch long and $\frac{1}{1000}$ inch broad at its thickest part, and as its name implies, it is walking-stick in shape, rounded at the base, and acuate-attenuate at the other end. The curve of the basal end is at right angles to the stem, which is broadest just below the junction of the handle. There are eight enlargements of the axial canal, which, where perfect, is about $\frac{1}{10}$ of the diameter of the spicule. The first, at the basal end, is a globular swelling ending in a simple enlargement of the axial canal; the second is at the junction of the handle and stem, and is a long and wide space, increasing gradually in breadth to a certain point, and then diminishing suddenly to the normal dimension of the axial canal. Then follows a short normal canal, which suddenly enlarges and again very gradually diminishes, to its original calibre. This third enlargement is much smaller than the first, and the shape is the reverse of the larger one. A very short piece of axial canal follows, and it again enlarges for the fourth time in a manner similar to that observed in the third enlargement, but to a greater extent. A fifth and broader enlargement succeeds, with barely any intervening normal axial canal, and it is well rounded in front and angular towards the end of the spicule. Three others succeed, and they are small, but of the same general shape. The last ends in a normal canal which opens externally, and has not its termination within the spicule.

The shape of the enlargements—elongated tear-shaped—is very remarkable, and they differ amongst themselves only in length and breadth. The second enlargement occupies at least one-half of the width of the spicule, and the fifth quite three-quarters of it; so that there is little solid matter left around. This very remarkable spicule has the enlargements of its axial canal filled with the balsam in which it is mounted.

Now, a second specimen of the same type, has the axial canal inflated and swollen here and there, but the enlargements do not resemble those of the spicule just described in size, shape, or position (Fig. 1*a*).

A third specimen of the same shape, has the whole axial canal enlarged about three times its normal width; and a fourth specimen is quite normal, having an excessively delicate axial canal without any swellings, and being minute and tubular. The length of these spicula is about $\frac{1}{100}$ inch, and the greatest breadth $\frac{1}{1000}$ inch.

It is tolerably evident that the symmetrical and very striking

enlargements of the axial canal are not normal, and that they have been superinduced upon a narrow and delicate tube structure.

Several verticillately spined acuates, measuring $\frac{1}{200}$ inch in length and $\frac{1}{1200}$ inch in extreme breadth, were examined. In one type the spinules on the spicule are well developed and not very close, the base is rounded and spined, and the shaft attenuates and ends in a point. Several specimens have normal axial canals, and two have them expanded. Thus in one (Fig. 2) the canal is enlarged in the base, and increases in breadth for one-third of the length of the spicule, and then it narrows suddenly with a rounded contour into the normal dimension. It enlarges again, suddenly, to about three times its usual diameter, and narrows slowly to again expand and diminish before reaching the end of the spicule, which is very slightly open. A second form, resembling that just noticed in external configuration, but with less projecting spinules, has the axial canal occupying two-thirds of the swollen base and larger half of the spicule, and it then narrows to close to the end, where it becomes open. Only one long and tapering enlargement exists (Fig. 2*a*). Another type, with more numerous and smaller spinules, has the axial canal enlarged as in the form last mentioned (Fig. 2*b*).

A sub-attenuate, cylindrical, entirely spined spicule $\frac{1}{300}$ inch long and $\frac{1}{1100}$ inch broad, has the axial canal slightly and equally enlarged for about one-fourth of the length; it then expands rapidly with a rounded contour, and diminishes slightly, and forms a large rounded canal in the rest of the spicule (Fig. 3). Other spicula of the same form have only a very delicate, normal, tubular axial canal.

Cylindrical spicula very slightly bent, with terminal inflations, these last only spined. Such a spicule $\frac{1}{100}$ inch long and $\frac{1}{1200}$ inch broad, has a perfectly plain cylindrical body, and in the centre, for a small space, a normal axial canal; but on either side, it enlarges about five times, terminating in rounded ends in the extremities of the spicule. These great expansions are filled with air in the specimen (Figs. 9, 9*a*).

In another specimen, basally spined but otherwise resembling it, a great enlargement has been broken across, and there are two smaller swellings with a short normal part (Fig. 9*b*).

There are many whole and fragmentary spinulate and fusiformi-spinulate spicula in the deposit, and many specimens are normal, the axial canal being very delicate and normal, and the usual globose enlargement in the head of the spicule is very small or it may be linear.

The departures from the normal type are numerous, and may be treated under different heads. (1) Enlargement of the axial canal, with opening at the small end of the spicule. In one

instance (Fig. 4*), the axial canal is enlarged close to the point, and it opens widely with a very thin cylinder of silica around it. Then it narrows to the normal size, and again enlarges so as almost to fill up the rest of the spicule, bulb included. There is the veriest shell of solid matter surrounding it. Other specimens show uniform enlargement of the axial canal and of its usual globular ending, the dimensions being from just beyond the normal to almost complete filling up (Fig. 4*a*). The enlargement in the bulb is often irregular in shape.

(2) Enlargement with perforating tubules reaching the axial canal from the exterior (Fig. 4*b*). The sides of the axial canal, where penetrated by the minute tubules from without, present a rotten appearance, the outline is ragged, and erosion seems to be going on irregularly, from within outwards. Higher up, the canal is normal, but at the basal termination there is a long and somewhat irregular swelling.

(3) In another specimen, numerous perforations occur in the bulb and several in the stem, and some reach the axial canal, which is regularly and symmetrically dilated, or simply enlarged in its calibre. This appears to be the commonest type of departure from the normal condition of the axial canal (Fig. 4*c*). The perforations, when seen from above, show circular disks differing in their light-transmitting power from the rest of the spicule, and when seen sideways are very small sections of cylinders, hollow and about the breadth of a normal axial canal, but sometimes they are larger (Fig. 4*d*).

There are some acuate spicula in the deposit, rounded at one end, attenuate at the other, slightly bent or straight, and they present several modifications of the axial canal, which normally is very linear and equal in its calibre.

A slightly bent form (Fig. 5*a*), about $\frac{1}{1000}$ inch in breadth at the larger end, has the axial canal slightly open at the end, and there is an enlargement of its calibre, which is rounded and greatest close to the larger termination. In another specimen, the canal, open at the small end, does not widen for some distance; but then it enlarges gradually and has its calibre so increased that the axial canal can be recognized as a tube nearly filling the whole of the remainder of the spicule (Fig. 5*b*).

There is the top of a large acuate spicule in one of the preparations, which has become fractured in consequence of thinning, owing to a great development of the axial canal. The tip of the spicule (Fig. 5*c*) has an open axial canal slightly enlarged, which increases in size in the form of a reversed cone with wavy margins, until a cylindrical expansion is produced nearly filling the body. The parietes became so thin that after fracture but a layer of silica remained to indicate the position of the former nearly solid spicule.

Probably there are more acerate spicula in the deposit than any other forms, and there are two kinds of them; one the common acerate, and the other a fusiformi-cylindrical, bent more at the ends than in the middle and bluntly pointed. The normal axial canal is present in some, but it is abnormal in most of these spicula.

The first abnormal kind (Fig. 6) is $\frac{1}{100}$ inch long and $\frac{1}{1300}$ inch at its greatest breadth. The axial canal reaches the point and is exceeding minute, but it soon widens out slightly, and then suddenly still more so, and nearly fills up the end of the spicule. Then it narrows to the normal calibre and reaches close to the other extremity of the spicule. In another spicule of the same dimensions, the axial canal is normal at one end, and is very slightly enlarged in that half of its course; but in the other it increases gradually in size, and then rather suddenly diminishes, forming a rounded end, out of which passes a delicate normal tube for a short distance, and it does not reach the termination of the spicule.

A third kind is $\frac{1}{33}$ inch in length, and is very slender. The spicule, Fig. 6*a*, is open at both ends. At one end the axial canal is large and gradually diminishes to the normal condition. At the other end the axial canal is small and gradually enlarges in the first fifth of the spicule, and then diminishes and becomes normal, joining the similar condition of the canal at the other termination. A fourth specimen of an acerate is of the dimensions of $\frac{1}{100}$ by $\frac{1}{1300}$ inch (Fig. 6*); it is marked on the surface by erosion, by pits and irregular eminences, and it is open at both ends. The axial canal fills nearly the whole, except at one end where it is only slightly enlarged and open.

One of the most striking forms of spicula, and probably the commonest in the deposit under consideration, is an acerate more bent at the ends than midway, and which is fusiformi-cylindrical and rather bluntly pointed.

It was the study of numerous specimens of this type, that led to the belief that the remarkable enlargements of the axial canal were subsequent to a normal condition, in which the tube was excessively narrow and did not reach quite to the end of the spicule.

A normal spicule is about $\frac{1}{60}$ inch long and $\frac{1}{1000}$ inch broad.

The first example of a departure from the normal type of the axial canal, is in a spicule of the same dimensions. Near to one end, the width of the axial canal is slightly greater than normal, it then suddenly increases to nearly the whole breadth of the spicule, and occupies a quarter of the length, then it gradually diminishes in width, tapering down to that of the normal canal. This great enlargement occupies two-thirds of the whole spicule, and there is only a short normal tube leading from it, and which ends in a

small enlargement conico-cylindrical in shape, with a globular or convex base towards the end of the spicule. (Fig. 7.)

A second spicule of the same shape, with enlargements of the axial canal, is $\frac{1}{100}$ inch long and $\frac{1}{1100}$ inch broad (Fig. 7*a*). There is a great enlargement at each end and a smaller one in the middle which is joined to one of them by a normal axial canal, and to the other by a globular and minute enlargement. The enlargements are very elegant in their outlines, being long cylindrical cones with rounded bases, or with the base with two curves. A third spicule has three enlargements of the axial canal of nearly equal size and they are united by short and very slightly enlarged tubes. The enlargements are conico-cylindrical, and the broad bases of two are towards each other (Fig. 7*b*.)

Another group of these spicula having the same shape and dimensions has the specimens with the axial canal open at one or both ends. In one form the open canal is slightly enlarged, and then it contracts to the normal breadth, then it expands rapidly and again contracts gradually, terminating in a long, normal axial canal. This ends in a small tear-shaped enlargement leading to a canal which is open at the end of the spicule. (Fig. 7*c*.)

A second spicule of this type has its ends widely open, leading to great cylindrical enlargements which occupy nearly all of it. They have rounded extremities, which are connected by a slightly enlarged tubular canal. In this instance there is but a very thin film of siliceous covering, over the expansions. (Fig. 7*d*.)

Lastly, a fractured specimen has an open axial canal at the remaining end, and this enlarges into three small elongate cavities leading to a large one which gradually occupies the whole inside; excessive thinning of the spicule at last determined its fracture. (Fig. 7*e*.)

A large form of this spicule is fractured at both ends and it lies with its curvature placed vertically. There is a slight widening of the axial canal in the middle of the spicule, and on either side there is a series of enlargements of considerable width, the last being broken across by the process of thinning of the wall. On one side of the central portion, there are four enlargements and part of a fifth, and on the other there are three and part of a fourth. All are long, broad, and have more or less conoid outlines with rounded bases. (Fig. 7*.)

Cylindrical-fusiform, blunt or sharp pointed, straight spicula are rare in the deposit. In one with blunt ends (Fig. 8) there is a very large axial cavity ending in a normal axial canal, which, however, enlarges slightly in one part of its length. This spicule is open at the end near to the large cavity, and the axial canal ends very close to the other termination.

Fig. 8*a* is a magnified view of a sharply pointed spicule which

is open at both ends, and has a slight enlargement near the extremities. One part of the end of the spicule has been eroded off.

It is evident, that in nine forms of sponge-spicula taken from one sounding under conditions of great pressure and cold, remarkable enlargements of the axial canals are observable.

The symmetry and elegance of the outline of the enlargements are without exception, and the usual shape is elongate cylindro-conical, the base being convex in a single or double curve. The position of the base varies; often the cones are placed in more or less apposition by their points, but the reverse is seen also. Evidently the curves of the enlargements, as seen in outline, do not relate to the lines of the original deposit of the silica.

In some instances the enlargement is filled, or partly filled, with air, and in the others Canada balsam has flowed in; and whilst in some the parietes of the enlarged spaces are smooth and glassy, in others they are minutely punctate, and present a worn appearance. In some enlargements there is a greenish tinge and distinct granular matter.

The careful examination of a great many spicula proves that specimens of every typical spicule, whether it be acuate, acerate, basally-rectangulate, spinulate, dirhophalate, basally or entirely spined, may have different kinds of enlargements of the axial canal. In some instances the normal condition exists.

Hence the enlargements are abnormal, and subsequent to the development of the spicule.

In investigating the possible causes of these enlargements, I was led to examine the spicula with higher powers. Three other structural changes, which have already been alluded to in the descriptions, were then carefully noticed in them, and it appears that they relate to the enlargement of the axial canals.

First. The axial canal, instead of ending a short distance from the end or ends of the spicula, may be open at one or both extremities. This condition is usually accompanied by simple enlargement of the axial canal near the end, or slight general and equal enlargement of the calibre of the canal. But in many of the spicula under consideration, there are constrictions at different distances up the canal, and conoidal enlargements.

Secondly. Minute cylindrical perforations occur, passing from the outside of the spicule through the siliceous structure to reach the axial canal. They are usually perpendicular to the path of the canal, are very narrow, and are straight. Sometimes a circular pit on the surface denotes one of these in the commencing stage, or one may have only got through one-third or one-half of the way to the axis.

In some specimens the outer surface of the spicule has a dull and worm-eaten appearance from the presence of numerous separate

depressions, circular in outline and very shallow. This appears to be the first stage of the process of penetration, which always occurs from without.

The third condition is the commonest, and is a combination of the two others. Open axial canals and penetrations from without, into the normal or enlarged canals are to be observed in the majority of the spicula noticed in this communication.

It is evident that these abnormal states of the spicula tend to diminish the quantity of silica in them, and are destructive in the long run. The number of fragments of spicula in the deposit is very remarkable, and most of them appear to have been produced by gradual thinning of the spicule from within outwards, and by solution of continuity due to repeated penetrations.

Fracture from thinning is shown in Figs. 7*e*, 7*d*, 5*c*, 9*b*, and 10; and from the presence of perforations in Figs. 4*d*, 10*a*, 5.

Mr. H. J. Carter, F.R.S., noticed, in 1873, that spicules of sponges were often penetrated from without, by holes leading to minute canals, and that the axial canals, when they were open at the end, became enlarged. He does not seem to have found the axial canal penetrated by the minute canals from without, and no other than simple enlargement of the axial part was noticed by him. He wrote: *—"Taking the siliceous sponge spicule by itself we find that it is subject to two kinds of wasting or decay, viz. one which takes place in the interior or wall of the central canal, and the other on the surface, the former frequently occurring in the living sponge, and the latter in the substance of the spicule after death. The wasting which takes place in the wall of the central canal is recognized by its increasing size, which in some cases goes on until the spicule is reduced to a mere shell, or it takes place only at the ends of the spicule, where the central canal at these points presents a funnel-shaped cavity diminishing inwards or towards the centre of the spicule. In either case the cause is not apparent. As this occurs in the living state, it is just possible that the central canal of the spicule, which begins in a simple cell, may sometimes become so dilated as to assume the form of a full-grown spicule with little, if any, vitrification, and then appear as a mere shell." "On the other hand, the destruction which takes place on the surface of the spicule and extends into its substance, presents itself under three different phases, viz. first it consists of a simple superficial circular cavity, which may increase in size and depth; second, of a simple, straight, uniform, blind tube extended vertically into the substance of the spicule; and third, of a smaller tube of the same kind ending in a globular dilatation. In each instance it seems to be produced by the eroding action of an organized cell; that is, in specimens of the two latter mounted in Canada balsam, a granuliferous cell may

* Ann. and Mag. Nat. Hist., xii. (1873) p. 456, plate xvi.

be observed to occupy the inner extremities respectively, recalling strongly to mind the appearance of the saprolegneous cell *Pythium* when working its way through the cell-wall of *Spirogyra*. Kölliker gives good figures of the first recorded form of this, merely observing that it is a 'peculiar degeneration.'" *

Mr. Carter's figure of the penetrations from without, appended to his essay, resembles those which I have seen to a certain extent, but none of those in the spicula mentioned in this communication end in globular swellings. My friend does not appear to have seen them opening into the axial canal, nor has he seen the remarkable series of enlargements of the axial canal now noticed. Certainly they do not relate to young sponge spicula or the ground-work spicula around which a mature one could develop.

The cylindrical borings, for such they are, are found on all parts of sponge spicula, and are very common. Very few of the spicula of the deep-sea deposit now under consideration are without them. The diameter of the tubes, which are invariably cylindrical, differs, $\frac{1}{7000}$ inch being exceptionally large. Some are mere lines under high powers, and in some spicula the first stage of the boring process is well seen (Figs. 5, 6**, 6*). Moreover, concavities occur in greater or less numbers, or they may be solitary, on the outside of the spicule: they are circular in outline, and are below the level of the outside of the spicule. Others represent the next stage, where boring has not quite reached the axial canal (Fig. 12*b*). The last stage, in which the axial canal has become very slightly enlarged close to a perforation into it, is shown in Fig. 12*a*.

Fig. 4*d* is a part of a spicule showing three penetrations, which reach far in towards the axial canal, five large ones which reach the canal, and three which are seen from above and resemble circular disks of light. Besides, there is at one extremity of the piece, a ragged penetration which has evidently had to do with the fracture. In this instance the axial canal is abnormally wide, but has not its calibre irregularly enlarged. Fig. 10*a* is a view of the end of a spicule with penetrations from without, and a gradually enlarging canal. Fig. 11 is a view of a very curiously shaped spinulate, and the three borings are incomplete. Fig. 11*a* is of part of the axial canal of another specimen, in which entrance of water from without has been made possible. Fig. 12 is of the entrance of a perforation into an axial canal on an acerate; the canal is slightly enlarged, and in one place is beginning to form a symmetrical space. Under the Microscope the texture of the wall of the canal is not clear, but that of the perforation is bright. Figs. 5 and 12*a* show the progress of erosion of the axial canal. Fig. 12*b* shows incipient penetrations, one being oblique. Fig. 14 shows a multiplication of penetrations and enlargements on a long acuate.

* 'Icones Histologicæ,' der feinere Bau, p. 83, pl. viii., fig. 10.

The greatest number of spicula with moniliform and conical enlargements of the axial canal, have these penetrations from without, to which attention has just been directed. This is illustrated in Figs. 1, 1*a*, 7, 7*b*, 9*a*, 4*c*, and 13, 14. In some instances the perforating tubules enter enlargements of the axial canal. It is now necessary to inquire into the cause of the open condition of the ends of axial canals and of the perforations.

An open state of the axial canal at the ends of spicula, is very rarely seen in perfectly formed and adult spicula of ordinarily located spongida, and occlusion is brought about during growth. It may have happened that some of the spicula now under consideration are immature, but it certainly is not the case with many which are figured. In none is there any evidence of solution of the spicule from without, down to the ends of the axial canal, for these are of the usual shape. Several spicula, such as Figs. 2, and 2*a*, 2*b*, have no perforating cylindrical tubes on them, so that the open condition of the axial canal is solely in relation to the series of enlargements of its calibre. These may be immature forms, but the curiously bent spinulate 11*a* is not immature, and there is an evident opening of the canal.

With regard to the enlargements of the axial canal, Bowerbank has shown that the inner layers of silica of spicula are more readily dissolved than the outer by reagents, and Sollas has enlarged our knowledge on the subject. But the remarkable shapes produced within the spicule, bear no relation to the method in which the silica was originally deposited.

Where a perforating tubule or tubules exist, there is not so much difficulty in accounting for the solution of the silica around the axial canal. Mr. Carter, in a letter to me, is good enough to remind me of my communication to the Royal Society * on the Thallophytes which perforate the walls and septa of hard corals, and to express a belief that these penetrations are produced by somewhat similar organisms to *Achlya penetrans* nobis. What he has seen I have already noticed, and I can confirm its truth. There is, of course, an indisposition to credit that a delicate cell-structure could dissolve silica and penetrate into its mass; but if carbon dioxide is the solvent in the case of the coral, it will be efficacious in that of the organic colloid silica of the spicule. Certainly there are no ramifications within the spicula as there are within the corals affected by the *Achlya*, and the sides of the penetrations are sometimes, but not always, as bright and polished as the outside structure of the spicule itself. The following, however, are the appearances which may be seen in many of the penetrated spicula in the deposit now under consideration. But before noticing them, it is necessary to explain that the spicula, of

* Proc. Roy. Soc., xxv. (1876) p. 238, pl. vii.

which there is such a singular variety in the deposit, did not grow where they were found; many are moderately deep-water and some shallow-water forms, and all have (in all probability) been washed here and there, and have sunk down into the abyss.

Firstly, it is to be noticed that many spicula have multitudes of circular markings or depressions on them, which are concave towards the centre of the spicule. In some, where there are a few of these depressions, the circular outline is very distinct, and they are never elevated, but are erosions in the outer layer of silica. In several of the depressions minute elongate bodies are to be seen (Fig. 16*a*), closely resembling the non-ciliated zoospores of *Achlya* when immature or contracted after drying.

In one specimen a distinct piece of a greenish cell projects from the depression, which had become a tube reaching some distance inwards. Several spicula have on them faintly green bodies, circular in outline, very small in height, and with a faint, darker central spot. These occupy the position and are of the dimensions of circular depressions about to be. They project, of course, higher than the spicule at a side view, and cover it when seen from above (Fig. 16*b*). They singularly resemble the zoospores of *Achlya penetrans*.*

Within the enlarged axial canals, especially in two spinulates, there are minute granules in a plasma. In one (Fig. 16*c*) four or more granules are in the globular enlargement of the bulb, and a minute granulation is seen in the canal. In the other, the granules are smaller, but are aggregated into groups (Fig. 16*d*).

In many axial canals there is a substance which refracts light differently to the silica of the spicule and the surrounding balsam. It is pale green in colour, and infinitely minutely granular. It may contain refracting bodies like very small nuclei.

Many axial canals have a worm-eaten appearance on their sides, and the silica is rotten for some distance, producing irregular enlargement (Figs. 4*b*, 4*c*, 5‡, 12*a*), as if there had been special points of erosion from within, and granules are seen in the hollows in the sides of the canal.

All these observations tend to enhance the hypothesis that the penetrations from without are produced by a very lowly organized plant; that when penetration into the axial canal has taken place, the organism fills it and proceeds with its erosion, enlarging the calibre; and that sea water, making its way in, with or without the assistance of the Thallophyte, will gradually increase the diameter and length of the canal. After a while thinning occurs and rupture of the spicule, or it may be so drilled as to become discontinuous. Evidently there is no relation between the shapes of the enlargements of the axial canals thus produced, and those of the

* Loc. cit., pl. vii., fig. 61.

spicula; neither can any connection be determined between the position of penetrating tubules and the size, shape, and distribution of the pretty conoidal enlargements.

Examination of deep-sea soundings, given to me by Dr. Wallich, F.L.S., and by H. T. Whittell, Esq., one of the Fellows of this Society, from the Atlantic and South Pacific, from depths as great as 2000 fathoms, show sponge spicula with perforations and enlarged axial canals, but none of the extraordinary shapes are present. The vast pressure to which the spicula were exposed as they travelled along the sea floor to their resting-place, is the only additional cause which can be associated with the occurrence of the unusual forms of the axial canal; but the *modus operandi* does not appear.

During the progress of these investigations I have been struck with the fact that, whilst erosion of the spicula has gone on greatly within, the most delicate spinules of the outside coat of silica are intact. In the same deposit, however, there are worm-eaten-looking spicula, as has already been mentioned, and some spicula which, with enlargement of the axial canal, present irregular scalings off of layers of the siliceous outer covering (Fig. 15), but the cause of the one is evidently connected with vegetable organisms, and that of the other does not appear clear.

It appears that time has something to do with the amount of solution, and that the erosive action of the Thallophyte is more rapid than that of the pressure and chemical action of the sea itself. One cannot but be struck with the evidences of the solution of organic silica which is proceeding on the floor of the sea as well as at the surface. The sponge spicule and the Radiolarian of the deep ooze are eroded and wasted in the same degree as the Diatomaceæ of the surface. The causes may be partly different, but biological energies influence the solution on the whole more than the physico-chemical.

The biological cause has been noticed in this communication in relation to the spicula found at great depth, and Mr. Carter has connected it with common sponge life; but what the physico-chemical action may be is a matter which requires careful consideration.

Of course the explanation at hand is pressure and carbon dioxide held in suspension in sea water. That the pressure is enormous at even moderate depths is true, and it is equally certain that pressure assists the dissolving or combining power of carbonic acid gas. But is there any free carbonic acid gas in the sea?

What deep-sea deposits I have seen (thanks to the kindness of members of this Society), calcareous and siliceous, or both, in their nature, do not carry conviction to my mind that they have been subject to erosion under the influence of free carbonic acid gas,

and which in the case of the carbonates resulted in a formation of soluble bicarbonates. In some of the deep-sea deposits calcareous fossil forms have been dredged up, but their delicate structures have not been dissolved. Many of the corals which Pourtales, Moseley, and I have described and which were from great depths, are marvels of perfection of structure. Yet they and the fossils are presumed to be under such chemical conditions that after death they must rapidly disintegrate and be dissolved; that is to say, they have been subjected to enormous pressure of sea water containing considerable amounts of carbon dioxide. That there is solution of silica and carbonate of lime going on in the depths and on the surface of the sea, is evident enough, but it takes place very slowly and minutely, and not in the degree or amount which it ought, did the deep and surface sea hold a little free carbonic acid gas in suspension. The quantity of dissolved silica and carbonate and bicarbonate of lime in the sea is really very small.

It will be a boon when chemists inform us what are the results of pressure assisted by bicarbonates and carbonates in solution, leaving out the free carbonic acid gas, upon organic silica, and on the calcareous tests of invertebrata. Until that occurs we must demur to the belief in the existence of that free carbonic acid which, acting during the whole history of the globe, has permitted calcareous sea floors to be perpetuated as rocks, and the most delicate ornamentation of fossils to be preserved, and plenty of visible carbonate of lime to exist on sea floors. Probably the very slow and slight process of solution depends upon the presence of atmospheric air and of oxygen gas in water with or without pressure. An oxygenating process is quite as credible as the other, and indeed is more so, for it has a greater scientific basis than that propounded by the believers in a sea whose waters resemble those of a gazogene.*

Beautiful and symmetrical as are the spaces and cavities within the spicula, they must be acknowledged to be enlargements of normal axial canals, and to be evidences and tokens that even the siliceous spicule obeys the inevitable laws of change, death, and dissolution. The spicule which has lived, has to decay, and may live again in another form. And this new one will have, by-and-by, to illustrate in its turn, the æsthetics of destroying nature—of that environment which develops the grand outlines of the hills as their rocks crumble away, and which condescends to beautify the tiny microcosm as it passes away and plays its little part in the scheme of evolution.

[Since this communication was read I have found sponge spicula

* On the evening of the reading of this communication the Society received the admirable work on the 'Chemistry of the Norwegian North Atlantic Expedition,' by Tornö. That able chemist disproves the hypothesis which has been so useful to Sir Wyville Thomson, and which maintains the existence of important quantities of carbonic acid gas in a free state in the sea.

with disk-shaped depressions on them at least $\frac{1}{2000}$ inch in diameter. Sometimes the depression leads to a deep penetration into or towards the axial canal, which has the same diameter of $\frac{1}{2000}$ inch. In one instance a spicule was crowded with them, and presented a very remarkable appearance, for the refraction of the hollowed out and removed parts which are filled with Canada balsam, differs much from that of the siliceous spicule. One specimen shows the appearance drawn by Mr. Carter; in another the circular depression on the outside of the spicule leads to a globular penetration without the intervention of a cylindrical portion. The globular part has a greater diameter than the external circular erosion. In many instances bodies resembling nuclei and granular protoplasm, faintly green in tint, are observed in the penetrations and in the axial canal.]

## X.—*On a Blue and Scarlet Double Stain, suitable for Nerve and many other Animal Tissues.* By B. Wills Richardson, F.R.C.S.I., Vice-President University of Dublin Biological Association.

(*Read 9th June*, 1881.)

The following method of double-staining sections in blue and scarlet, and sections of the spinal cord in particular, I have found very satisfactory. The differentiation of many of the component parts of the cord, for example, being decided and most instructive, the cells being blue or bluish-grey with darker shaded nuclei, the axis cylinder of each conducting fibre being also of the darker tint, while the white substance of Schwann is scarlet modified a little in brilliancy by the adjoining bluish tints.

For conciseness' sake, I shall take one section through this double-staining process:—

Place a section sliced from the hardened spinal cord, say of an ox (prepared according to one of the ordinary methods followed by microscopists), in a bottle about half-filled with a deeply tinted watery solution of Atlas scarlet, made by adding drop by drop to filtered water a very deeply coloured solution of the scarlet in Price's glycerine. To the watery solution a few drops of alcohol may be added. Short wide-mouthed pomatum half-ounce bottles with good corks are excellently suited for staining purposes.

Examine the section from time to time, say every third day, and when found to be stained of a deep scarlet tint, it is ready for the second stage of the process. Sections, however, may be left in the solution for many weeks without risk of becoming too dark for this stage.

Take the section from the bottle, and wash it in methylated spirit to remove any of the scarlet stain that may be loosely adherent to the surface. The small white saucers (ounce) used by artists in water colours are very useful for section-staining, and other microscopic purposes.

When washed, place the section in a second saucer containing a blue watery solution, made by adding a drop or two of a deep-coloured solution of soluble blue in glycerine, to filtered water.

This is a critical stage of the process, for if left too long in the blue fluid, the double-staining will not be satisfactory.

From fifteen to twenty minutes I have usually found sufficient for the purpose. The thinner the section, the more rapid the action of the blue stain.

When sections have been in the blue fluid for a few minutes, the blue generally shows signs of fading; to check which, add a

drop or two of glacial acetic acid. This, indeed, may be done previous to submitting sections to the action of the blue stain.

When the section has acquired the desired depth of colour, which is to be ascertained by lifting it occasionally out of the solution on a sable pencil and placing it in methylated spirit, it should be at once washed in the spirit, and submitted in a third saucer to the action of absolute alcohol to remove all the water imbibed by the section.

In practice I have found that a light purple tint is sufficiently deep for sections of the spinal cord and of some other tissues.

From a quarter to half an hour will suffice for the removal of the water by the alcohol.

The section is now ready for final mounting. Transfer it to a glass slide, and when the spirit has nearly volatilized, clear with clove oil, and mount in one of the dammar solutions. I prefer Klein's solution.

It must not be supposed that this double-staining process is suitable for animal tissues in general. I merely recommend it as capable of producing excellent didactic results, and when carried out with care will amply repay the histologist for the trouble given to it.

I should be wanting in gratitude were I to conclude without acknowledging that I am indebted for the blue and the scarlet colours to the courtesy of Messrs. Brooks, Simpson, and Spiller, of 50 Old Bond Street, London, who obligingly forwarded to me samples of Atlas scarlet and the blue, both of which are perfectly soluble in water.

# SUMMARY

OF CURRENT RESEARCHES RELATING TO

# ZOOLOGY AND BOTANY

*(principally Invertebrata and Cryptogamia),*

# MICROSCOPY, &c.,

INCLUDING ORIGINAL COMMUNICATIONS FROM FELLOWS AND OTHERS.*

## ZOOLOGY.

### A. GENERAL, including Embryology and Histology of the Vertebrata.

**Mesoblast of the Vertebrata.**†—Professor O. Hertwig is of opinion that this layer is not split off, but is folded off from the endoblast, and that this occurs on either side of the blastopore. The complete separation of the mesoblast from the endoblast happens some time after its development. The bands of cylinder-epithelium below the primitive groove or chorda-endoblast begin to be folded in, and give rise in time to a solid rod of cells (the notochord). Meantime the parietal and visceral lamellæ of the mesoblast unite below this layer, and separate from it and from the enteric endoblast. The large polygonal cells of the latter now press more and more towards the middle line, and finally fuse with the lower surface of the notochord. It follows, therefore, that the closure of the permanent enteron on its dorsal side, the separation of the mesoblastic sacs from the endoblast, and the development of the chorda dorsalis are processes in development which are very intimately connected with one another.

**Embryonic Sternum.**‡—Students of Professor W. K. Parker's monograph on the shoulder-girdle and sternum should read an essay by Herr G. Ruge, on the development of the breast-bone and its connections in man, which has just appeared.

**Development of Parrots.**§—Dr. Max Braun continues his important studies, which, notwithstanding the title, are not confined to parrots.

* The Society are not to be considered as responsible for the views of the authors of the papers referred to, nor for the manner in which those views may be expressed, the main object of this part of the Journal being to present a summary of the papers *as actually published*, so as to provide the Fellows with a guide to the additions made from time to time to the Library. Objections and corrections should therefore, for the most part, be addressed to the authors. (The Society are not intended to be denoted by the editorial "we.")

† Jen. Zeitschr. f. Naturwiss., xiv. (1881) Suppl. Heft, pp. 110–13.

‡ Morph. Jahrb. (Gegenbaur), vi. (1880) pp. 597–602.

§ Arbeit. Zool.-Zoot. Inst. Würzburg, v. (1881) pp. 205–341 (5 pls.).

In dealing with the primitive groove, he reaffirms the statement that it is a median thickening of the ectoderm, and that the endoderm takes no share in forming it. This groove soon begins to shorten at both ends, and becomes thicker at the anterior, and thinner at the posterior end.

The medullary tube has a double mode of origin; the greater part arises by the formation of a groove in the ectoderm, but the hinder portion is at first solid (medullary cord). In its anterior part, and in front of the primitive groove, it is purely ectodermal in origin; in the region of the groove the mesoderm takes a part in the formation of its floor; behind this, it is solely of mesodermal origin. As to the difficult question of how this hinder part is formed, the author points out that there are three possible ways. The cord may have grown from the point where there is a connection between the medullary tube and the ectoderm backwards into the thickened portion of the primitive groove; or there may have been no connection with the ectoderm; or, thirdly, the mesodermal elements may only secondarily have entered into its composition. To this last view the author would appear to incline.

The chorda dorsalis has already been shown by Braun to be developed from the axial part of the mesoderm. So far as the anterior part of the primitive groove extends, the chorda arises from it, and there is an intimate connection between the dorsal surface of the notochord and the future ventral limit of the medullary tube. In many cases the deeper axial cells of the primitive groove collect in the middle line, and become bounded off laterally, and this separation takes place from below upwards. In other cases the chorda dorsalis becomes marked off more anteriorly, at the point where the ectoderm is already separated in the middle line from the mesoderm, and here, of course, it appears to be altogether mesodermal in origin.

The communication between the dorsal medulla and the endoderm, which was first seen by Gasser,* has been further extended by Braun, who has detected two other communicating orifices; he here discusses his results, and compares them with what has been described by other observers, but he refuses to follow some of them into the formation of impossible hypotheses.

His investigation into the development of the caudal end of the body has led him to the interesting result that, after the formation of the rudiment of the tail, there is a communication at its hinder end between organs so different in function and developmental history as the dorsal medulla and the caudal enteron.

**Structure of the Mammalian Ovary.**†—In a second essay on this subject, Mr. Jules Macleod deals with the orang-outang, with *Semnopithecus*, *Cercopithecus*, *Macacus*, and *Cynocephalus*, and with one lemur *L. nigrifrons*.

Among the Primates, the human species is the only one in

* See this Journal, *ante*, p. 217.
† Arch. de Biol., ii. (1881) pp. 127–44 (2 pls.).

which the ovary has been examined with any care. The arrangements, macroscopically observed, are much the same in the orang as in man; the Catarrhine apes all very closely resemble one another; while the lemur, instead of having its ovary attached along its whole length to the mesovarium, has it free at both ends. In general histological structure, all the forms examined present the same characters as the human ovary; but in the macaque there is a true ovarian epithelium, of which no more than a trace is to be found in the other forms, nor is there in it any cell which can be regarded as the primordial ovum.

**Structure of the Epidermis and Rete Malpighii in young Fowls.***—Professor C. Frommann has been investigating these structures in chicks just extruded. He finds that the protoplasm of the epidermic cells largely exhibits a reticular structure; in the periphery of some cells he finds a layer of hyaline protoplasm. There is no thickened membrane, but the surface of the cell is invested by firm fibres, which form more or less regular areas, and are in part connected with the filaments of the network, and in part with coarser fibres which pass into the cell. The nuclei are distinguished by their low refractive power, and by the rarity of formed elements. They generally contain one, but in some rare cases two or three nucleoli.

The rete Malpighii forms a continuous layer of protoplasmic plexuses, in which there are no cell-boundaries, and in which the proportionately large nuclei stand closer than they do in the epidermis. Long and coarse fibres are here comparatively rare, and are most frequent in the deeper layers of the rete, where they are set perpendicularly or obliquely to the surface. There is generally a large nucleolus, and some pale, fine fibres; but there is no plexus. The limiting fibres are coarser than in the epidermis, but diminish in width towards either end.

**Albuminiparous Glands in Amphibians and Birds.†**—Dr. P. A. Loos comes to the conclusion that these glands have the same structure in the two groups.

After an introduction, the author gives an account of the scaleless Amphibia. He finds that the nucleoli, the nuclei, and the plasmatic plexus are slightly modified parts of the same living substance. The presence of a nuclear membrane in the albumen-cell appears to be at first sight a matter of importance, but as this is merely an excreted product, the author thinks it has no real morphological significance. The glandular epithelial cell generally consists of a plexiform plasma, in the meshes of which there are a large number of albumen-drops. These increase in size gradually and lose their high refractive index. The growth of these parts brings about a certain increase in the extent of the cell-membrane; the drops become polyhedral in form, and the intermediate tissue is reduced to a minimum. When the membrane finally gives way, the albumen escapes from the cell.

* Jen. Zeitschr. f. Naturwiss., xiv. (1881) Suppl. Heft, pp. 56-8.
† Zeitschr. f. wiss. Zool., xxxv. (1881) pp. 478-504 (1 pl.).

**Eyelike Spots of Fishes.***—Professor F. Leydig comes to very different conclusions concerning these organs to those which were arrived at by Dr. Ussow.†

After a careful investigation of the subject, he finds that the bodies in question have no sensory function, points out how they differ from the eye, and dilates upon their striking resemblance to the electric or pseudo-electric organs of certain other fishes. Those of them which may be truly spoken of as "eyelike" have no real morphological resemblance to an eye, while the others, which are "mother-of-pearl" or "luminous organs," exclude all possibility of their being sensory bodies. The presence of a "tapetum" suggests the probability of their being organs by which the scanty light of great depths may be reflected, but observations on this subject are still required. In conclusion, it is suggested that the luminous function may only be a secondary duty of these structures.

**Forces of Living Matter.**‡—T. Bernstein elaborates a theory upon this subject which starts with the assumption that in living organisms, as in nature generally, *force* undergoes two changes of condition: (1) the "an-energic," consisting in passing into the potential from the active condition, and (2) the kat-energic, reversing this process. The latter is naturally the one which is most commonly observed; the storage of force by plants under the influence of sunlight is an example of the former, which is, however, not known to occur in animals. Living matter can hence be defined as "that which by virtue of a change of substances in its interior produces anenergic and katenergic processes." The vital force which produces these processes, but which does not operate in dead material, is explained by the writer as chemical, and as due to the changes which occur in the molecular combinations of the chemical substances of which the matter is composed. His explanation is, in fact, based on that chemico-physical theory of life which has long ranked among advanced biological speculations.

The particular form of force evoked by contact with foreign bodies is called "contact force," and includes the forces of cohesion, friction, capillarity, electrical tension, catalytic action, operation of ferments. Living matter consists of molecules endowed with cohesion. The visible composition of protoplasm, which is seen under the Microscope to contain granules, agrees with this theory of its being composed of chemically differing molecules, a conclusion supported by the fact that the more granular it is, the greater its chemical activity. The molecules represented by the protoplasmic granules react upon the liquid which surrounds them, and under the influence of their "contact force," take up matter for growth and thus become centres of activity, whose subsequent structure is the more complicated according as more molecules of different structure

* 'Die Augenähnlichen Organe der Fische' (8vo, Bonn, 1881) 100 pp. (10 pls.). See also article in Pop. Sci. Rev. by Prof. F. J. Bell, v. (1881) pp. 221–34 (1 pl.).

† See this Journal, ii. (1879) p. 849.

‡ Preisverk.-Programm. Univ. Halle, 1880.

unite to form them. Examples of growth by contact force are those exhibited by artificial cells, in which the cell-membrane causes new material to be taken up. Electrical contact gives another example; in a Daniell's cell, for example, electrical tension causes the accumulation of oxygen and acid radicles at the zinc, of hydrogen and copper at the copper pole, katenergic action taking place at the former, anenergic at the latter point. The contact of living matter with different substances appears to this writer perhaps to cause electrical phenomena which may be in part the source not only of nerve and muscle activity, but also of the changes of the cell. The existence of electromotive force at the poles of the cell-nucleus is perhaps shown by the changes which it undergoes during cell-division, but chemical agencies are probably also at work, so that the entire process is probably electro-chemical.

Herr Bernstein considers some of his protoplasm-molecules to be actually visible in the form of the "disdiaklasts" of striped muscle. These are crystals, and thus exhibit the action of those molecular forces which cause crystallization in inorganic matter. Hæmoglobin is another example of the same thing. A progressive development of the fundamental molecules of living matter has probably gone on side by side with that of the living organisms which they form, their changes being promoted, as in those organisms, by the necessity of adaptation to changing conditions.

**Hypotheses with regard to Perception of Light and Colour.***—A posthumous work by the late Franz Boll, whose brilliant investigations into the physiology of the eye are well known, sums up his chief views on the functions of the retina as follows:—

He considers that the layer of this organ which is sensitive to light "is composed exclusively of a very great number of separate, individual, and independent points, every one of which is in immediate contact with its neighbour. . . . These separate, independent points I call 'sight-elements.'" He finds that each sight-element possesses two marked properties, the one that of causing complete perception of light and colour according to our ideas of these things, the other a "local peculiarity," or special sensitive property peculiar to each element. The separate elements have been recognized; they are placed at regular intervals. The peripheral retinal elements, being imperfectly sensitive to light and colour, form an exception to the first rule. The existence of the second property finds support in many physiological facts and in some taken from the microscopic anatomy of the sensory nerves, which show that a localized sensation must travel for a long distance isolated in a primitive nerve-fibre; hence the number of local centres should be exactly that of the nerve-fibres contained in the optic nerve. The actual sight-elements have an anatomical as well as a physiological existence, but they are made up of the pigment-cells, the rods, and the cones, and do not consist of any one or two of these elements alone. This theory is supported by

* Arch. f. Anat. et Physiol., 1881 (Physiol.) p. 1. Cf. Naturforscher, xiv. (1881) pp. 220–2.

the structural peculiarities of these parts, by their almost universal occurrence in the Vertebrata, and by their exclusively making up the mosaic layer. The pigment-cells alone are never absent in any members of the series (with the possible exception of albinos), and are indicated with more or less distinctness throughout the entire kingdom, in connection with the function of sight.

Professor Helmholtz adds (*l. c.*) a further exposition of Boll's views on this subject. Boll had hoped to be able to assign one of the three elementary conceptions of colour to each of the three above-named anatomical elements. The outer cylinders of the rods, with their red pigment, were found to be most rapidly decolorized by green light, and thus probably are the recipients of perceptions of *green.* The movement of the granules of the pigment-cells were apparently affected by white and blue alike in equal measure, and hence these cells probably are sensitive to the *violet* rays. The cones are left to be assigned to the perception of *red*, a conclusion rendered probable by the slight development which they present in those, the peripheral, parts of the retina which are insensitive to that colour. Against Helmholtz's objection that the yellow spot ought on this hypothesis to afford no sensation of green, Boll advanced the insufficiency of our knowledge of the structure of this part of the retina. Helmholtz adduces physical facts relating to the colours as bearing on the question, viz. that in accordance with their different respective relations to refractive media, the violet rays would find their point of concentration in front of the red ones; that while the small amount of absorption necessary for the action of the violet would be furnished by the cones, the large amount necessary for the red would hardly be found in the pigment-cells; on the other hand, the great photochemical activity of the violet rays would probably lead to the penetration of the red pigment of the rods by a small number of them and to their consequent action on the pigment-cells and other parts lying behind.

**Action of Light in the Formation of Hæmoglobin.***—The importance of light in connection with the production of chlorophyll having been thoroughly established by many experiments, and this green vegetable colouring matter showing a close analogy with the colouring matter of the blood, Messrs. G. Tizzoni and M. Fileti have endeavoured to establish by experiment the fact of a similar influence of light upon hæmoglobin. A summary of the results of their experiments, which have extended over several months, shows that in a rabbit twenty-three days old the amount of hæmoglobin diminished when the animal was kept in the dark but otherwise well cared for; the weight of the body at first increased and then decreased. In a few days from the commencement of this decrease (two months after the beginning of the experiment) death took place. Rabbits of the same age and from the same litter, and kept under the same conditions, with the exception of the admission of light, were used in comparison, and these invariably manifested increase in weight of body and in amount of hæmoglobin.

* Atti Accad. Lincei, iv. (1880) p. 168.

Results of anatomical importance were obtained from an examination of the marrow of the bones, the spleen, and the lymphatic glands of the subject thus experimented on.

**Phosphorescence in Organic and Inorganic Bodies.*** — No thorough explanation of the phenomenon of phosphorescence has hitherto been put forward. The presence of oxygen is known to be necessary to it, and heating up to upwards of 150° C. produces it in certain organic bodies, but the latter circumstance does not of course afford any clue to its occurrence in living organisms. In the year 1877, however, B. Radziszewski discovered that the organic compound lophin phosphoresces at 10° C. and lower temperatures, provided that oxygen is present, that the reaction is alkaline, and that chemical action is slow. A number of other organic bodies prove to be similarly endowed.

The chemical formulæ expressing the oxidation of these substances show an analogy with that of phosphorus in process of oxidation, in that the oxygen molecules are broken up and produce an uneven number of atoms. This difference, however, exists, that ozone, which is formed in the case of phosphorus, is not produced in presence of alkali, which is, as seen above, a necessary accompaniment of phosphorescence in these newly-discovered instances. The properties of breaking up the oxygen molecule and forming ozone and peroxide of hydrogen, and of absorbing the ozone when formed, are possessed chiefly by the terpenes, especially oil of turpentine, and by the aromatic hydrocarbons. This results in the evolution of light in the case of almost all the ethereal oils, oil of turpentine, bergamot, cajeput, &c., provided that oxygen is present, that the reaction is alkaline, and that more or less heat is applied; the aromatic carbon compounds also act thus, but not under the same circumstances; they require exposure to the rays of the sun, with access to the air, together with addition of soda and some heat. The property may be regained, if lost, by renewal of the action of the air and of direct sunlight.

The fats, and especially the fatty oils and their component parts, belong to the same category of substances; thus oleic-, elaidin-, castor-oil-, brassidin-, and other acids, with their salts or soaps, and their glycerin ethers, or fatty oils proper, have the power of slowly ozonizing oxygen and giving out light under an alkaline reaction. Some of the alcohols, viz., those containing more than four atoms of carbonic acid in the molecule, phosphoresce under an alkaline reaction; as also do all the higher monatomic members of the group when warmed with potash or soda. The four little known bodies, taurocholic, glycocholic, and cholic acid, and protagon, conduct themselves in a similar manner.

The compounds lecithin, cholesterin, spermaceti, wax, grape sugar, and other substances formed in the body, also give light under certain circumstances. Possibly the small quantities of the bases soda and potash occurring in the body may be compensated for by the known

* Liebig's Annalen der Chemie, cciii. p. 305. Cf. Naturforscher, xiii. (1880) pp. 352–3.

fact of their replacement by organic bases of the formula $R_4NOH$, and also by cholin and neurin. Probably the light emitted by the fat of *Trachypterus iris*, containing, as it probably does, in common with many parts of the body and many vegetable organisms, e. g. the agaric fungi, the compounds lecithin, cholesterin, and spermaceti, may be due to the neurin and cholin into which lecithin is known sometimes to become decomposed. In all these cases slow oxidation is necessary. If it is too rapid, phosphorescence developes into burning, from which it is distinguished only by the more limited number of atoms of oxygen which are at one time in process of reaction with the body. The identity of the light afforded by the above organic bodies with that of living organisms is shown by the spectroscope.

From what has been said, it is probable that increase in luminosity brought about by stirring or shaking the luminous body is caused by the greater access of oxygen which is thereby produced.

**Peculiarities in Marine Animals.***—In exhibiting some living marine forms, Professor Haeckel directed attention to (1) the hinder half of a young *Amphioxus*, from the centre of which there projected the naked notochord, which had lived thus for eight days and still exhibited lively movements; this was a case of a "partial Bion." (2) Young Ephyra-larvæ of *Aurelia*, which exhibited very considerable and remarkable variations in their mode of development, and showed all stages between complete metagenesis and a simple direct development. While most of the *Ephyræ* were developed by the well-known formation of strobila, some "persons" arose directly from the *Scyphostoma*, and some at once from the gastrula of the *Aurelia*. In addition to this, there were the most various stages between the Scypho-polyps and the Ephyra-Medusæ; persons in which the umbrella was partly provided with tentacles and partly with sensory organs having been observed.

**New Biological Journal.**—Under the title of 'Biologisches Centralblatt' Dr. Rosenthal, the eminent Professor of Physiology at Erlangen, has, with the assistance of Professors Reess and Selenka, commenced to issue a periodical, of which it is announced that 24 numbers of 32 pages are to appear during the year. The aim of the journal is to give abstracts of published biological researches (signed by the writers), and original communications will, under certain conditions, also be included. The first number contains notices of several important books, such as that of H. Müller on the Fertilization by Insects of Alpine Flowers, the notice of which is written by the author; Nencki on the Biology of Bacteria, by Dr. Wolffberg, of Bonn; and Munk on the Functions of the Cortex of the Cerebrum, which is noticed by Dr. Exner. The only English paper noticed is Dr. Heneage Gibbes 'On Human Spermatozoa.'

* Jen. Zeitschr. f. Naturwiss., xiv. (1881) Suppl. Heft, pp. 141–2.

## B. INVERTEBRATA.

**Invertebrate Fauna of the Firth of Forth.***—Mr. G. Leslie and Dr. W. A. Herdmann have published a report on this subject. The first part contains the Hydroida, Alcyonaria, and Echinodermata; the second, the Protozoa, Polyzoa, Crustacea, and Tunicata; and the third the remaining groups. In the last there is an interesting note by Mr. M'Murtrie on *Patella vulgata.* He says, "Where a spring of fresh water rises on the shore above low-water mark, a little to the east of Granton East Harbour, a thin form of *P. vulgata*, pale, and with a silky surface, takes the place of all other forms, and is plentiful. It may be due merely to the influence of fresh water, but I suspect a corroding quality in the spring. *Tectura testudinalis*, in the same place, is worn very thin." Some groups are not completely worked out.

**Fauna of the Swiss Lakes.**†—Herr Asper has found a rich fauna inhabiting the small lake of the St. Gotthard at 2154 metres above the sea; it includes larval Diptera, numerous species of *Lumbriculus*, some *Pisidia*, and a few small Calanid *Copepoda.* In the night a number of pelagic *Daphniidæ* and larvæ of gnats were obtained on the surface. At the edge of the lake occurred numerous *Neuroptera*-larvæ, a few Planarians, among them a fine black species to be hereafter described.

In the Lake of Ritom, in the Piora valley, of 1829 metres elevation, were found on the stones near the shore large quantities of *Lymnæa auricularia*, the Engadine *Hydra, H. rhætica*, a large colonial Bryozoon, and numerous *Neuroptera*-larvæ. The deeper parts contained scarlet *Calanidæ* and colourless *Daphniidæ;* but mud from a depth of 55 metres contained no trace of animal life.

### Mollusca.

**Olfactory Organs and Nervous System of the Mollusca.**‡—Dr. J. W. Spengel argues for the unity of the Molluscan type. He commences by pointing out that numerous references are to be found to a structure which has never been fully worked out—the so-called "ciliated organs"; when the innervation of these parts is examined, there is no doubt that the bodies so named in the Heteropoda, Pteropoda, and Pulmonata are homologous, and that an organ found in the Prosobranchiata, to which another significance is ordinarily attached, clearly belongs to the same category.

In examining such a Prosobranchiate form as a species of *Trochus*, *Turbo*, or *Vermetus*, we find three pairs of ganglia grouped around the pharynx, of which two are ordinarily known as the cerebral and pedal respectively; objecting to all the various names which have been given to the third pair, the author proposes to distinguish them as the *pleural* ganglia. To the cords which connect the centres of the same side the author follows Professor Lacaze-Duthiers in applying the term *connective.* These last form a triangle at the angles of which there

* Proc. R. Phys. Soc. Edinb., vi. (1881) 106 pp.
† Arch. Sci. Phys. et Nat., iv. (1880) p. 406.
‡ Zeitschr. f. wiss. Zool., xxxv. (1881) pp. 333–84 (3 pls.).

are placed the ganglia, and the two triangles are united across the middle line by two commissures. The *visceral commissure* is long, and, while connecting the pleural ganglia, has a number of ganglia (visceral) developed on it. In the forms under examination (Chiastoneura) the arm of the commissure from the left pleural ganglion passes ventrally and to the right, and then bends towards the dorsal surface, goes to the left, and extends to the right pleural ganglion. On this two or three ganglia are developed. From one, the supra-intestinal, a strong nerve gives off branches to the gills and left half of the mouth, but goes chiefly to the so-called "rudimentary gill" or colour-gland of T. Williams. This is the olfactory organ of Dr. Spengel, who finds that it consists of a large mass of nervous substance, invested by a layer of epithelium, into which nerve-fibres distinctly pass.

In examining the Orthoneura, the writer finds that this organ is more complicated in structure; for example, there is an enormous ganglion in the centre, with a central fibrous mass and peripheral cells, around which are pinnate filaments of connective tissue, lacunæ, and ciliated epithelial cells; nerve-fibres pass into the lamellæ of the filaments. The author then proceeds, by an account of the arrangement of the nervous system in the Orthoneura, to demonstrate the homology between this organ and the similar one in the Chiastoneura, and finds in addition that the symmetry of the visceral nervous system is due to secondary connections between its ganglia and the pleural ganglia; probably there are no true Chiastoneura, in the sense in which that word is used by v. Ihering.

We arrive, therefore, at this first general conclusion—that the classification of certain groups of the Gastropoda into Chiastoneura and Orthoneura is untenable.

The author then discusses the Heteropoda, where he finds the nervous system to consist of two cerebral and two pleuropedal ganglia, between which the typical connective and commissural fibres may be distinctly developed, or almost lost; but in all cases, a nerve for the olfactory organ is given off from the supra-intestinal ganglion; the arrangement in the Heteropoda being referable to what obtains in the Prosobranchiata, it is concluded that they are Prosobranchs modified by adaptation to the pelagic mode of life. The only exception is to be made for the Zeugobranchiata (*Haliotis* and *Fissurella*), which have two gills developed, one on either side, with which may be associated *Patella;* to understand these, however, it is necessary to make reference to the torsion of the body which appears to have taken place. This appears to have caused the gills and olfactory organs to move round a circle the centre of which is the anus, and the effect of this is to bring the left gill and the connected olfactory organ in front of the anus to the right side, and the right gill and its olfactory organ to the left. The Anisobranchiata are Zeugobranchs in which the organs of the right side have disappeared, and those of the left have taken on a compensatory greater development.

After discussing other groups, the author comes to the consideration of the Pulmonata; here he again finds that the "nouvel organe d'innervation" of Lacaze-Duthiers is olfactory; owing to the want of

constancy in the position of the organ, Dr. Spengel is compelled to believe that this group has arisen from one in which it was present on both sides, and not from the Tectibranchiata, which have only one on the right side.

Similarly the "ciliated organs" detected by Gegenbaur in the Pteropoda are referred to the same category.

Speaking, for convenience, of a primitive mollusc, we find that such a creature had an enteron running from before backwards, a median heart with two auricles, which received the efferent vessels from two gills, probably from two kidneys, which opened to the right and left of the anus; and that this creature had a symmetrically arranged nervous system, consisting of three pairs of peri-œsophageal ganglia, connected by three connectives and three commissures; of these the visceral commissure was very long, and had intercalated in it several visceral ganglia, of which the two lateral gave off nerves, which passed to a ganglionated sensory (olfactory) organ placed at the base of either gill. By turning this creature through 180° we get the organization of the Zeugobranch Prosobranchiata; thence by the loss of the organs of the right (in the primitive mollusc left) side, we get the Aniso-branch Prosobranchs (except Heteropoda). The forms which did not undergo this change gave rise to the Opisthobranchs, Pulmonata, or Pteropods. These considerations lead to the following scheme of classification:—

GASTROPODA.

1st Order. *Streptoneura.*
  1st Suborder. Zygobranchia.
  2nd ,, Azygobranchia.
2nd Order. *Euthyneura.*
  1st Tribe. Ichnopoda.
  2nd ,, Pulmonata.
  3rd ,, Pteropoda.

Coming next to the Lamellibranchiata, the author gives a revised account of the nervous system. He thinks that it consists of two cerebral (or, rather, cerebro-pleural) ganglia, and two pedal ganglia, with two cerebro-pedal connectives and a visceral commissure, in which there are two visceral ganglia, each of which is connected by an olfactory ganglion with an epithelial olfactory organ. Save, then, that there are no pleural ganglia, we here find the arrangements of the typical primitive mollusc. The olfactory organs as seen in *Arca Noœ* appear to be represented by a transverse band of pigment placed between the hinder end of the foot and the anus; where, as in *Anodonta* and *Unio*, there is no pigment, we find a high, cylindrical epithelium.

The last class to be considered is that of the Cephalopoda, and here the author is far less full than in the previous cases. He thinks that it is possible to derive the group from his primitive mollusc; if the funnel corresponds to the foot, the whole circumanal plexus has passed to the ventral surface; if the arms correspond to the foot, then the pallial cavity is dorsal in position. In either case the visceral com-

missure is excessively shortened. These last two forms, with the Solenoconcha, are euthyneural, but are all to be distinguished from the Gastropoda by their remarkable retention of bilateral symmetry, while each shows its own distinctive characters. Everything, however, points to the fact that all the groups here included under the Mollusca, and whatever their special difference, have a common ancestor and present a common type.

**New and Rare Cephalopoda.***—Professor Owen has published an illustrated memoir, the concluding portion of which deals with "Cephalopods remarkable for large size;" *Plectoteuthis grandis* must have had a total length of 33 feet. After discussing the evidence on the subject, the author concludes that sufficient "has been obtained to demonstrate that the greatest bulk in the molluscous sub-kingdom is attained by members of its most highly organized class;" and he points out that in past times there were also great variations in the size of the lower or tetrabranchiate order of Cephalopods; their shells ranged in size from those no larger than a modern *Spirula* to an Ammonite four feet, and an Orthoceratites six feet in length; and the "constructors and occupants of such shells may have approached in size to the larger naked Cephalopods recorded in the present paper."

**Giant Squids.†**—If any doubt still remained as to the real existence of *Architeuthis*, the matter might now be regarded as definitely settled, for Professor A. E. Verrill reports that in October 1875 there were, as he learns, a large number dead or dying cast upon the Grand Banks; of these the fleet from Gloucester, Mass., obtained between twenty-five and thirty, which they used as bait for cod. They were, without the arms, 10–15 feet long, and 18 inches in diameter. The arms were almost always mutilated, but the part that remained was three to four feet long, and about as large as a man's thigh. "One specimen, when cut up, was packed into a large hogshead tub, having a capacity of about 75 gallons, which it filled. This tub was known to hold 700 lbs. of codfish. The gravity of the *Architeuthis* is probably about the same as that of the fish. This would indicate more nearly the actual weight of one of these creatures than any of the mere estimates that have been made, which are usually much too great. Allowing for the parts of the arm that had been destroyed, this specimen would, perhaps, have weighed nearly 1000 lbs." One was taken with arms 36 feet long.

**Ink-bag of the Cephalopoda.‡**—M. P. Girod finds that in *Loligo vulgaris* this bag is much less developed than in *Sepia officinalis*, though it presents the same general characters. The gland has the form of a Phrygian cap, and at the upper part of its free edge has an orifice, by means of which it communicates with the reservoir. In *Sepiola Rondeletii* the bag is either simple or trilobed; in the latter case there is on either side an elongated body which is connected by a constricted portion with the central mass, the presence of which

* Trans. Zool. Soc. Lond., xi. (1881) pp. 131–70 (13 pls.).
† Amer. Journ. Sci., xxi. (1881) pp. 251–2.
‡ Comptes Rendus, cxii. (1881) pp. 966–8.

appears to have escaped previous observers. The pouch is enormously developed during the reproductive period; the central mass is pyriform in shape, and gives off two flattened prolongations; the angle between these is covered by a silvery elastic membrane, and contains an ovoid yellowish gland; the investing layer contains small cylindrical cells and others which are four times as large, are spherical in form, and are derived from the former. In *Octopus vulgaris* the anterior part of the wall is largely adherent to the wall of the bladder, and the free part only forms a diaphragm, in the centre of which is the orifice for the ink; no silvery elastic layer could be detected in this species. The author promises to give figures in illustration of his results.

**Regeneration of Lost Parts in the Squid.***—Prof. A. E. Verrill has observed numerous instances in *Loligo Pealei* and *Ommastrephes illecebrosus* of torn-off suckers having been reproduced, as well as of the reproduction of entire tentacular arms. These regenerated parts are mostly of smaller size, and the author suggests that it is probable that some of the normal European species of *Loligo* that have been based on the smaller size of the tentacular arms or of the suckers are due to similar cases of regeneration.

S. Richiardi has also published† a note on two cases of the reproduction of the arms of *Octopus vulgaris*.

**Enemies of Ostreiculture.‡**—M. A. Giard discusses certain animals which are, or are supposed to be, inimical to oysters. He defends the species of *Polynoë* from the charges that have been brought against them, and states that they only live among and not on these molluscs. The most terrible enemy is the sponge *Cliona celata*, which destroys the shell by boring. A small Annelid of an unnamed species of the genus *Leucodora* is also partly to blame; the author calls it *L. sanguinea*. In these cases there appears to be a kind of chalk-"hunger," and the same cause is used as an explanation of the eroded character of the shells of *Lymnæus* and *Helix* in certain localities or in captivity; and it may be that the same form of want will explain the perforating habits of the Echinid *Strongylocentrotus lividus*.

**Mollusca of the Gulf of Mexico.§**—Mr. W. H. Dall has made a preliminary examination of the results of the 'Blake' dredgings in the Gulf of Mexico in 1877–8, and gives the following as the most interesting and important deductions which seem to result from the facts before him. The collection contained about 500 species, or excluding Pteropods and some other groups, 462 which are considered in the paper.

(1) The facts already known, that certain species of molluscs have a very limited vertical range, forming respectively a littoral and an abyssal fauna, are supplemented by the additional hitherto

* Amer. Journ. Sci., xxi. (1881) pp. 333–4.
† Atti Soc. Tosc. Sci. Nat. (1881) pp. 248–9.
‡ Bull. Sci. Dep. Nord, iv. (1881) pp. 70–3.
§ Bull. Mus. Comp. Zool. Camb., vi. (1880) p. 85.

unrecognized fact that a fair proportion (say 20 per cent. in the present case) have a vertical range which extends from the true littoral region (less than 50 fathoms) to the depths of the abyssal region (250 to 2000 fathoms), unlimited by temperatures actually encountered.

(2) Of the species with great vertical range (from less than 100 to more than 500 fathoms), the smallest part (10 per cent.) are of groups which have been regarded as belonging to or characteristic of the shores of cold or boreal areas. The next larger part (20 per cent.) belong to groups hitherto considered characteristic of shoaler warm or tropical waters, while more than 60 per cent. belong to groups not especially characteristic of the *littorale* of either region.

(3) Of the species found in the abyssal fauna without regard to their vertical range above it, 10 per cent. may be termed boreal, 13 per cent. tropical, and more than 75 per cent. uncharacteristic forms.

(4) Since the tropical forms belong to the same groups as those characteristic of the local littoral mollusc fauna, it is eminently probable that the abyssal regions have local faunæ proper to their various portions, and that a universal exclusive abyssal fauna, so far as molluscs are concerned, does not exist. This must be qualified by the admission of the existence in the abysses (as well as on the *littorale*) of ubiquitous species-forms; which, however, do not form a universal abyssal fauna any more than *Mytilus edulis*, *Saxicava rugosa*, and *Poronia rubra*, form a universal littoral fauna. The local nature of different portions of the abyssal fauna is also confirmed by the distinctness of the 'Challenger' molluscs from those of the 'Blake,' but a very small number appearing identical as far as a cursory examination could determine.

There can be no doubt that the uniformity of generally low temperatures (and consequently of food) affords special facilities for the wide distribution of boreal forms through the abyssal region. But where adjacent shores can (by washing and sinking) afford a different or greater variety of food without too excessive temperatures, local abyssal faunæ will probably always be developed, and with characteristics assimilated to those of the littoral fauna of the same part of the earth's surface. The present collection shows conclusively that a difference in pressure of some 120 atmospheres and in temperature of 41·5° has been sustained by different individuals of the same species without perceptible change in the external appearance of their hard parts or shells.

(5) The specific characters of many of the strictly abyssal species appear to exhibit a very remarkable degree of variation within supposed specific limits, although it would seem as if the conditions under which they live must be remarkably uniform. This would indicate that the tendency to variation is less dependent upon change in the existing environment than has generally been assumed.

The total number of littoral species recorded by Adams and D'Orbigny, throwing out those groups, like the Pteropods, not germane to the inquiry, is 580, as compared with 461 collected by the 'Blake.' The number of genera represented by the former is about 110, while

some 98 genera are found in the 'Blake' collection. The 461 species included in the last-mentioned collection comprise 210 which are littoral or do not reach great depths, while 251 are abyssal or ubiquitous. These numbers are of course approximate, and subject to correction, but probably not seriously in error.

Out of 48 species, of 44 genera, having great vertical range, 24 have a range of 500 to 750 fathoms; 17 have a range of from 750 to 1000 fathoms; and 7 have a range of from 1000 to 1555 fathoms. Bearing in mind that the absolute depth of the extreme range may be much greater than this, the astonishing fact is evident that the same species may experience a difference, between two of its stations, of the weight of nearly two miles of sea-water. The possibility of this of course lies in the permeation of the soft parts by the sea-water, thus equalizing the pressure. It is almost certain, however, that individuals from the great depths would die if removed to shoaler water, unless by extremely slow degrees.

It is noticeable among the deep-sea forms that the sculpture tends to be slight, the shell thin, pale or colourless, and in the spiral shells there is a tendency to a knobbing or denticulation of the posterior edge of the whorls at the suture. To each of these peculiarities there are, however, conspicuous exceptions.

Tables are appended giving in detail the statistics from which the foregoing conclusions have been drawn.

### Molluscoida.

**Tunicata of the 'Challenger' Expedition.***—Dr. Herdmann, in the third part of his preliminary report, deals with the *Cynthiadæ*, which family he re-defines as follows:—Body attached, sessile, or pedunculated; apertures four-lobed, or having less than four lobes; test coriaceous; rarely cartilaginous or gelatinous; branchial sac folded, with internal longitudinal bars, but no papillæ; stigmata straight; tentacles simple or compound. Of the four tribes of Savigny's genus *Cynthia*, two disappear, one being referred to the Molgulidæ, and the other having been shown by R. Hertwig to have been founded under a misapprehension; the others are retained as the sub-families *Cynthinæ* and *Styelinæ*, and a third—*Bolteninæ*—is now formed for the reception of the old genus *Boltenia*, the new *Culeolus*, and, probably, *Cystingia*. The author, as in his previous communications, gives a table to show the arrangement of the sub-families and genera.

In the genus *Microcosmus*, *M. Helleri* and *M. propinquus* are new; in *Cynthia*, *C. cerebriformis*, *C. fissa*, *C. formosa*, *C. arenosa*, *C. irregularis*, *C. hispida*, and *C. complanata* are new; in the genus *Styela* ten new species are described, and eleven in *Polycarpa*. The new genus *Culeolus* is formed for the reception of six deep-sea species of stalked simple Ascidians, which closely resemble in appearance and in many points of their structure *Boltenia*, from which they are to be distinguished by the structure of their branchial sac. "It is merely a skeleton compared with that organ in other simple Ascidians. The

* Proc. R. Soc. Edinb., xi. (1881) pp. 52–88.

system of fine longitudinal or interstigmatic vessels is entirely wanting, so that the large vessels are not broken up into true stigmata." All the species of this genus belong to the abyssal zone, and have an exceedingly wide distribution, speaking to the uniformity of the abyssal fauna.

**Organization of the Simple Ascidians.***—M. Ch. Julin describes some structures which as yet have awaited the technical arts of modern histologists. To put his results fairly, it will be necessary to consider, with him, the position of the Tunicate group.

After recapitulating the views of earlier naturalists, the author expresses his agreement with Kowalevsky, Fol, and Gegenbaur, who have insisted on the Vertebrate affinities of this class. He considers that there is a *ventral face*, along the median line of which there runs the endostyle or hypobranchial groove, and a *dorsal* which lies between the oral and cloacal orifice. There is an anterior or oral orifice, and a posterior or cloacal one. After a careful incision along the hypobranchial groove (directing the internal branchial cavity towards the observer), it is seen (1) that the portion of the branchial cavity which is characterized by the presence of the branchial clefts is distinctly separated from the region near the buccal orifice by a circular swelling, in which there lies a groove (the pericoronal groove of Lacaze-Duthiers). This pericoronal welt bounds posteriorly the coronal or buccal region, in which there are inserted, in a circle, the tentacles. Along the median dorsal line there runs a fold, which is part of the wall of the branchial cavity; this is the *dorsal raphe* (posterior raphe of Lacaze-Duthiers). Near the anterior extremity of this raphe we see the anterior tubercle or vibratile organ. The *cloaca* is placed between the wall of the body and that of the branchial sac, and extends forwards as far as the pericoronal groove, and ventrally as far as the hypobranchial groove. Between the two halves of the peribranchial cavity there lies the interoscular region. (2) In the pericoronal welt there are to be distinguished an internal and an external lip. The former is a membranous and completely circular fold; the latter is also membranous at its side, but disappears ventrally and dorsally. (3) The anterior part of the dorsal raphe forms a swelling which is closely connected with the surface of the body, and is marked by a distinct groove—the *epibranchial* groove; the posterior part of the dorsal raphe is less projecting, and forms a membranous fold varying in character. (4) Along the median dorsal line, and in front of the inner lip of the pericoronal groove, there is a special organ, to which its finder, Savigny, gave the name of anterior tubercle; others have since called it the vibratile organ. The present author prefers the former of these, so far as the term *tubercle* is concerned; but as he regards it as homologous to the cerebral hypophysis in the Vertebrata, he prefers to speak of it as the hypophysial tubercle. In its interior there is an infundibuliform cavity, the base of which is anterior; it is flattened from above downwards, and opens on the surface of the tubercle by an orifice, the form of which is different in various species.

* Arch. de Biol., ii. (1881) pp. 59–127 (4 pls.).

The hypophysial gland is, with the nervous ganglion, situated in the interoscular region, and is regarded by the author as homologous with the glandular portion of the Vertebrate hypophysis. The nerve-ganglion has a cylindroidal form, is elongated from before backwards and flattened from above downwards. It does not increase in size with the species. In all the forms that were examined, anterior and posterior peripheral nerves were detected. The latter frequently divide, quite close to their origin, into a number of nerve-branches, but the former never give rise to more than two trunks, which go to innervate the buccal region. No branch is sent to the hypophysial tubercle.

After this preliminary account, the author proceeds to a detailed description of these parts in the four species *Corella parallelogramma*, *Ascidia scabra*, *Phallusia mentula*, and *P. venosa*; and after this to a histological description.

The general conclusions to which his studies have led him are the following:—

1. The orifice which, in Ascidians, serves for the entrance of water into the branchial cavity is the homologue of the mouth of Vertebrates.

2. Around the mouth there is a circular zone, limited externally by the pericoronal welt; this zone constitutes the buccal region. It gives insertion to the circlet of tentacles which forms the coronal circlet, and it is very probably homologous to the primordial buccal cavity of *Amphioxus*.

3. In this welt there are two semicircular grooves.

4. The dorsal raphe is provided with an epibranchial groove.

5. The hypobranchial, epibranchial, and pericoronal grooves do not directly communicate with one another.

6. The two latter are invested by a vibratile epithelium, and they probably have the function of driving towards the œsophagus the nutrient matters which are collected into a mucous mass by the aid of the secretion of the hypobranchial groove.

7. The ganglion consists of an external layer of grey matter, which is solely formed of unipolar ganglionic cells, and of an inner white substance, which is formed of nerve fibrils and smaller nerve-cells. There is a complete absence of neuroglia.

8. In some species (e.g. *P. mentula*) a large number of unipolar ganglionic cells lie outside this brain, in the surrounding connective tissue, and their prolongations are continuous with the white substance of the nervous centres.

9. In all Ascidians there is a glandular organ which, in its situation and its relations, its texture, and its probable origin, justifies us in regarding it as the homologue of the hypophysis cerebri of the Vertebrata. It is situated immediately below the brain, and contains an excretory canal, which has just the same characters as the similar canal in the Vertebrata. It opens by a ciliated infundibulum into the buccal region, and its orifice is situated on a special tubercle.

We know that at a certain period in development the hypophysis of the Vertebrata opens by a widened orifice into the primordial

buccal cavity, and, just as in the Ascidians, this orifice is placed in the middle line, immediately in front of the boundary line between the primitive buccal cavity and the anterior *cul-de-sac* of the digestive tube. In both cases the organ is well supplied with blood-vessels, and that of the Ascidians, just as that of the Vertebrates, appears to be epiblastic in origin.

10. The hypophysial tubercle has not, as has been supposed, any olfactory functions; no nerve goes to it, and there are no olfactory cells.

11. The body-wall of an Ascidian may be regarded as formed of the same parts as that of *Amphioxus*. Below the integument there is a layer of connective and muscular tissue, on the inner face of which we find the external epithelium of the peribranchial cavity.

The author concludes by giving a synonymic table of the terms applied to the different parts of the Ascidian here under discussion, and divides it into two halves, one anatomical and one artificial. The number of artificial terms is in some cases appalling, as may be seen from what is anatomically called the dorsal raphe. Among other terms this part has been known as the anterior vessel (of Savigny), the hypopharyngeal band (of Huxley), the posterior vibratile groove (of Fol), and the posterior raphe (of Lacaze-Duthiers).

Development of Lithonephria.*—In describing the embryogeny of this Ascidian, M. A. Giard points out that the study of it is facilitated by the fact that the ova are incubated by the parent, and in such a way that various stages may be found in one individual. He finds that the " cells of the green layer," or "*granulosa* Zellen," have an origin outside the ovule; they have migrated from the follicle, and penetrated into the yolk; and they are in no way developed from the germinal vesicle. Soon they swell, and their contents divide into six protoplasmic masses, their wall disappears, and they are slowly driven to the periphery of the egg. There is, owing to the abundant yolk, a remarkable condensation of the developmental history of this form. At stage " VIII." there are four coloured endodermal and four colourless ectodermal cells. At stage "XXXII.," and even before it, the egg distinctly exhibits the bilateral symmetry of the adult; at the nutrient pole there are two large and four small endodermal blastomeres; at the base of the two large ones six mesodermal cells form half an equator, three on each side. At the formative pole there are twenty cells forming an ectodermal hemisphere; the mesodermal cells are of an endodermal origin. By epiboly the mesoderm becomes covered by the ectoderm; the half equator becomes horseshoe-shaped. This is the rudiment of the notochord, which in ova that undergo equal segmentation appears so much later. The author points out that he has previously insisted on the fact that the stages from IV.–VIII., which physiologically represent a morula, morphologically represent a gastrula. Here he finds that up to stage XXXII. the egg is still a morula physiologically, although there is a mesoderm developed, and he thinks that embryonic condensation

* Comptes Rendus, xcii. (1881) pp. 1350–2.

may be defined as an advance of the morphological on the physiological state of the embryo.

Here, as elsewhere, the solid mesoderm developed around the prostoma appears before the cavitary mesoderm; the first gives rise to the skeletal and muscular organs, the other to the blood-vascular system and serous membranes proper. The striated muscle is not characteristic of either of these parts of the mesoderm, for it may, in the same individual, be found in the tail of the larva, and in the muscular layer of the heart.

**Anatomy of Pyrosoma.***—L. Joliet, in a further note, observes that the four primitive individuals in *P. giganteum* are to be found not at the closed but at the open extremity of the colony, and he explains how they are "incessantly pushed away" from the closed end by the development of their progeny. The nervous system of the primitive ascidiozooids has its two lateral posterior nerves terminating at two muscular cords, but in ordinary individuals there is only one of these cords, which receives both nerves, and is the morphological representative of both cords. The bundles forming the colonial muscular system are reported to be formed from modified cells of the "common transparent substance." The author cannot assent to the doctrine that the elæoblast represents the tail of the *Appendicularicæ*, and he looks upon it as affording a store of nutriment for the young. To exactly compare *Pyrosoma* with *Salpa*, we must take the cyathozooid and the agamic *Salpa* as equivalent terms.

**Australian Bryozoa.**†—Mr. R. H. MacGillivray forms a new genus *Diplopora*, for a species which he considers was described by Hutton as *Membranipora cincta*. The cells are divided into two parts, the posterior portion being much elevated, and there is a narrow transverse portion a little distance behind the mouth, and in front of the elevated part, deficient in calcareous matter and entirely membranous.

The other genus is *Densipora*, considered to belong to the family Diastoporidæ, and is represented by one species called *Densipora corrugata*, and considered to be described for the first time, but it has already been cited as living in Australia, and was considered to be *Heteropora cervicornis* of D'Orb. The description of the full-grown individuals seems to leave no doubt as to the relationship to *Heteropora*; but the young specimens, the author says, show Diastoporidan characters, and therefore he places it under that family. This observation is of great interest now that attention is being drawn to the class position of *Heteropora*, and living and young specimens have not been available for those who have entered upon the discussion, but if the present interpretation is correct it must entirely support the Bryozoan affinity of *Heteropora*. As this is very important, we give the description of the young specimen said to show its Diastoporidan character. "The smallest specimen I have is about one-twentieth of an inch in diameter, is discoid, of considerable thickness in the

* Comptes Rendus, xcii. (1881) pp. 1013–14.
† Proc. R. Soc. Victoria (not yet received).

centre, with the cells closely connate, vertical in the middle, and oblique towards the circumference. Among the marginal cells a few small pores are to be seen." This description would seem to us to also recall a young *Lichenopora*, and as there are many characters in the adult common to *Lichenopora* (*Discoporella*) and *Heteropora*, a comparison in the young and adult stage of these two genera may furnish important results.

The genus is described as "Polyzoary forming an encrusting mass, discoid when young, composed of numerous long, closely packed, tubular cells, continuous throughout the whole thickness, and with the orifice not projecting.

Mr. MacGillivray also describes two new *Catenicellæ* from Port Phillip Heads, and two *Adeonæ*, called respectively *Dictyopora Wilsoni* (closely allied to *Adeona arborescens* Kirch.), and *D. albida* var. *avicularis*, from the same locality.

A new genus *Urceolopora* is also defined, and a species *U. nana* described and figured. This "genus resembles *Calwellia* in its individual cells, but unlike all the Gemellaridæ, these are not arranged in pairs, but alternately."

**Tertiary Bryozoa, &c., from Reggio (Calabria).***—In a large quarto memoir of 460 pages, with maps and numerous plates, Professor G. Seguenza gives a list and description of 2686 species of fossils from the tertiaries of Reggio, representing Vertebrates, Molluscs, Bryozoa, Entomostraca, Echinodermata, Cœlenterates, and Protozoa, of which 445 are considered new and 994 of the total number are now known living.

A large number of these are microscopic fossils, and the Bryozoa have special interest as they are found in almost all the formations of the tertiaries, mostly in great numbers, and in a good state of preservation, and up to the present time but a few have been described from the province of Reggio. The species are distributed as follows in the various zones of the tertiary:—Tongrian, 7; Aquitanian, 5; Langhian, 3; Helvetian, 118; Tortonian, 81; Messinian, 0; Zanclean, 165; Astian, 77; Sicilian, 82; Saharian, 101.

It is to be regretted that the author is wanting in the courage which would have led him to cut away useless species and reduce the number of synonyms. The strong point of the memoir, as far as the Bryozoa are concerned, is the careful comparison with the species described in the classical works of Reuss and Manzoni, and if more detailed comparison is made with the living Sicilian fauna much will be added to our knowledge of the distribution of the Bryozoa, and as the range of variation can be better studied in the living fauna, the number of names of fossil species will no doubt be much reduced.

Now that the number of known Bryozoa is very large, with an extensive synonymy, and frequently changing generic significations, it sometimes happens that authors give names already in use, and on this account the names *Flustra denticulata*, *Lepralia eximia*, and

* Seguenza, G., "Le Formazioni Terziarie nella Prov. di Reggio (Calabria)," Mem. Accad. dei Lincei vi., (1880) pp. 445 (17 pls.).

*L. adpressa*, should be changed. We would also suggest a comparison of *L. Sturii* Rss. and *L. formosa* Sey. with *L. decorata* of Rss., and *L. elegantissima* Sey., *mitrata* Sey., and *thiara* Sey. with varieties of *Cribrillina radiata* Moll.

As examples of cases where species are considered to occur only fossil, but are living in the Mediterranean, we may mention *Lepralia eximia* Sey. (which is *Membraniporella nitida* Johns.) and *Eschara conscinopora* var. *pliocenica* Sey. living as *Microporella distoma* Busk, but neither of these have yet been published from the Mediterranean, and in fact as yet the Bryozoa have been but little studied in the extreme South of Europe and North Africa.

Professor Seguenza naturally employed the classification he found used by Reuss and Manzoni, but since the memoir was in the press a new classification has been introduced which we hope will be adopted in any future work from the same pen.

In regard to the generic divisions employed we see that both the genera *Pustulopora* and *Entalophora* are used. The first name was given by Lamouroux and the latter by Blainville for the same group, and both have since been used as synonyms, but Manzoni recently artificially separated *Entalophora* from *Pustulopora*, placing in *Pustulopora* those with few cells, considering the only difference to be that "in these the number of cells is greater than in *Entalophora*"; but this is quite arbitrary, and according to this arrangement different parts of the same specimen might belong to two genera.

In the species of *Terebripora* and *Spatipora* described there remains great difficulty in finding satisfactory characters by which they can be separated from *Ætea*, which spreads in such various ways that if each was taken as having specific value the number of recent species of *Ætea* would be largely increased.

This valuable memoir must be constantly referred to by all working at both recent and fossil Italian Bryozoa.

### Arthropoda.

#### *a.* Insecta.

**Germinal Layers of the Insecta.***—Professor R. Hertwig is led, from his observations on the Coleopteron *Acilius sulcatus* and the Lepidopterous *Noctua* sp.? and *Zygæna minos*, to see that the yolk-cells form the enteric glandular layer, but that they are not, as has been hitherto supposed, sharply distinguished from the invaginated cell-mass.

The gastrula-mouth has, from its mode of formation, the form of a longitudinal cleft, and the cylindrical ectoblastic cells at its margin pass into the small invaginated cells. When we compare the invagination of the Insecta with that of other animals we see that these small cells do not form the whole of the gastrula-sac, but that there are in addition to them yolk-cells; and both these elements must, therefore, be regarded as forming the primary endoblast, from which there is, in addition, developed the mesoblast together with the

* Jen. Zeitschr. f. Naturwiss., xiv. (1881) Suppl. Heft, pp. 127–8.

dermo-muscular and entero-muscular layer. After describing the stages of the development of these parts, the author points out that (1) the mesoblast and endoblast are shown to have primitively a common germinal layer, the various parts of which are only to be distinguished by the difference in the amount of yolk which they contain. (2) In consequence of the wealth of yolk the enteric glandular layer is very slow in taking on the characters of an epithelium. (3) The mesoblast of the Insecta is developed by being nipped off from the endoblast, and the cœlom is therefore primitively an enterocœle.

**Perfect State of Prosopistoma punctifrons.***—M. A. Vayssière points out the extreme interest which attaches to this rare Arthropod, the systematic position of which has been a subject of so much doubt; doubts which were expressed by Milne-Edwards in his classical work on the Crustacea. In 1869 Dr. Joly discovered the presence of tracheæ in the animal, and demonstrated the affinities of this insect to the Ephemeridæ.

The author refers to the resemblances which in its development the insect in question offers to the group just named, and says that its aquatic period of life is characterized by the complete coalescence of the thoracic somites with the anterior segment of the abdomen, and the consequent diminution in number, and more complete localization of the respiratory organs; there are only five pairs of tracheo-branchiæ, and the first two of them have but a feeble respiratory effect. After pointing out the characters of other genera, in which there is also a certain reduction or localization of the respiratory apparatus, M. Vayssière shows that there is also a marked concentration of the generative organs. The prothorax is intimately fused with the metathorax, and the carapace thus formed gives rise to a respiratory chamber, the water for which enters by two ventral apertures and passes out by a single dorsal one; this current is set in motion by the first two pairs of respiratory organs.

The nervous system is also concentrated; in addition to the cerebroid ganglion there is a single sub-œsophageal ganglion, and a very large thoracic ganglion which represents by itself the whole of the ganglionic chain.

The subimaginal and imaginal stages appear during the month of June; the integument becomes of a darker colour, the two halves of the carapace become separated, the head and thorax appear, while the mouth organs disappear. Soon the abdomen is developed, and the wings take on their definite form.

An account is then given of the external form of the perfect insect, and the author states that, as a result of his dissection of two females, he found a large number of ellipsoidal ova, not unlike those of *Cloe diptera;* the digestive canal was completely empty, and all its glandular organs had entirely or partially disappeared. The nervous system was as concentrated as in the nymph. The tracheal apparatus consisted of two lateral trunks, which gave off a number of branches to the

* Ann. Sci. Nat., xi. (1881) art. 1, 16 pp. (1 pl.).

whole of the body, and were connected by very short secondary trunks with four or five pairs of stigmata. The setæ of the adult are not so complicated in structure as are those of the nymph; the locomotor limbs are atrophied in the adult, while the wings are, as might be expected, very well developed.

**Habits of Ants.***—In a further communication Sir John Lubbock continues his account of his observations on ants.

In a former paper he gave a series of experiments made with light of different hues, in order, if possible, to determine whether ants had the power of distinguishing colours. For this purpose he utilized the dread which ants when in their nest have of light. Not unnaturally, if a nest is uncovered, they think they are being attacked, and hasten to carry their young away to a darker and, as they suppose, a safer place. He ascertained by hundreds of experiments that if he exposed to light most of the nest, but left any part of it covered over, the young would certainly be conveyed to the dark portion. In this manner he satisfied himself that the different rays of the spectrum act on them in a different manner from that in which they affect us; for instance, that ants are specially sensitive to the violet ray. He further desired to determine how far their limits of vision agree with ours. This interesting problem he endeavoured to solve as follows. If an ants' nest be disturbed, the ants soon carry their grubs and chrysalides underground again to a place of safety. Sir John, availing himself of this habit, placed some ants with larvæ and pupæ between two plates of glass about an eighth of an inch apart, a distance which leaves just room enough for the ants to move about freely. He found that if he covered over part of the glass with any opaque substance the young were always carried into the part thus darkened. He then tried placing over the nest different coloured glasses, and found that if he placed side by side a pale yellow glass and one of deep violet, the young were always carried under the former, showing that though the light yellow was much more transparent to our eyes, it was, on the contrary, much less so to the ants.

So far the author had gone in experiments already recorded. But he now wished to go further, and test the effect upon them of the ultra-violet rays, which to us are invisible. For this purpose, among other experiments, he used sulphate of quinine and bisulphide of carbon, both of which transmit all the visible rays, and are therefore perfectly colourless and transparent to us, but which completely stop the ultra-violet rays. Over a part of one of his nests he placed flat-sided bottles containing the above-mentioned fluids, and over another part a piece of dark violet glass. In every case the larvæ were carried under the transparent liquids, and not under the violet glass. Again, he threw a spectrum into a similar nest, and found that if the ants had to choose between placing their young in the ultra-violet rays or in the red, they preferred the latter. He infers, therefore, that the ants perceive the ultra-violet rays which to our

* Journ. Linn. Soc. (Zool.)—Not yet published.

eyes are quite invisible. Now, as every ray of homogeneous light which we can perceive at all appears to us as a distinct colour, it seems probable that these ultra-violet rays must make themselves apparent to the ants as a distinct and separate colour (of which we can form no idea), but as unlike the rest as red is from yellow, or green from violet. The question also arises whether white light to these insects would differ from our white light in containing this additional colour. At any rate, as few of the colours in nature are pure colours, but almost all arise from the combination of rays of different wave-lengths, and as in such cases the visible resultant would be composed not only of the rays which we see, but of these and the ultra-violet, it would appear that the colours of objects and the general aspect of nature must present to them a very different appearance from what it does to us. Similar experiments which Sir John also made with some of the lower Crustacea point to the same conclusion; but the account of these he reserves to a future occasion.

Some experiments made on the sense of direction possessed by ants are also described, and on their power of recognizing friends, with some facts which appear to show that ants, by selection of food, can produce either a queen or a worker at will from a given egg. Some ants observed in 1874, are still living and in perfect health—more than seven years old—by far the oldest insects on record.

### β. Myriapoda.

**Structure and Affinities of Carboniferous Myriapoda.***—Mr. S. H. Scudder, as the result of an examination of *Euphoberia major* M. and W., finds that the structure of the Carboniferous Euphoberidæ differs so much from that of the modern forms, that they cannot be referred to the Diplopoda or Chilopoda, but should be placed in a new sub-order, for which the name of Archipolypoda is proposed.

### γ. Arachnida.

**Anatomy of Epeira.**†—W. Schimkevitsch describes the chitinous layer of *Epeira* as being composed of three layers; the thickenings below the "lungs," which Bertkau regards as due to the coalescence of setæ, are said to be due to folds of these three layers. The structure of the sheath of the setæ is more complicated than is ordinarily supposed; it is composed of two funnels, one within the other, and having near the chitinogenous layers a common enlargement which opens by a wide pore. A general sarcolemma, enveloping the whole of a muscular fibre, is only to be observed on the spiral muscle of the poison-glands. The adipose cells of the cephalothorax are not, as Plateau thought, confined to the stomach, but are to be found in all the intra-organic spaces. The ganglia of the appendages give off, on each side, two nerves; the maxillary ganglion gives off three pairs.

After a discussion of various nervous and sensory parts, the author states that the sucking organ is provided with a veritable sphincter-muscle; the cells of the posterior stomach are altogether comparable

* Amer. Journ. Sci., xxi. (1881) pp. 182–6.
† Zool. Anzeig., iv. (1881) pp. 234–8.

to yellow hepatic cells. The liver itself opens into this stomach by four lateral ducts and by an unpaired azygos one, and there are also other smaller superior ducts for special acini. Unlike Claparède, the author detected a pericardium. The receptacula seminis are two in number, and are formed by membranous sacs. The vasa deferentia open into an ampullar enlargement, analogous to the uterus of the female.

### δ. Crustacea.

**Crustacean Deformities.***—Mr. W. Faxon describes and figures some of the more remarkable examples out of a collection of nearly 200 deformed lobster claws purchased by the Cambridge (U.S.A.) Museum. The malformations range from slight deformities resulting from incomplete restoration of lost parts, abnormal curvature of the fingers to such as may, from the enormous development of abnormal outgrowths, or the duplication of parts, be truly called monstrosities. The majority of the irregularities have clearly resulted from injuries received after moulting, before the new cuticle had been calcified, and are mostly confined to the big claws. It is pointed out that it would be a most interesting subject of study for any one who may come into possession of specimens in a fresh or alcoholic state, to determine what modifications of the soft parts—muscles, nerves, arteries, &c.—are brought about by the deformities.

The paper also contains a review of the various deformities which have been described among Arthropods, which the author divides into five categories:—(*a*) of deficiency—certain parts normally present being wanting—never congenital among Crustacea; (*b*) of excess, under which head fall most of the monstrosities among Arthropods; (*c*) of transformation, an organ being replaced wholly or in part by another organ—common in plants, but rare in animals; (*d*) of arrested development; (*e*) of hermaphroditism, frequent in insects, but only two cases recorded among Crustacea outside of those groups in which it is the normal condition—viz. Cirrhipeds and parasitic Isopods.

**Development of the Amphipoda.**†—B. Uljanin has principally investigated the ova of the species of the genus *Orchestia*. These, when just laid, he finds to be coloured dark-violet and to be completely opaque; but the coloured spheres all belong to the nutrient yolk or deutoplasm. There is a chorion, but no vitelline membrane, and on account of their opacity nothing can be said as to the germinal vesicles of these eggs. While within the brood-sac of the mother, a circular groove divides the egg into two completely equal halves; the greater mass of the egg is, however, unsegmented, and in all the latter phases segmentation appears to be always superficial.

After the division into four equal parts, four very large amœboid cells may always be found within the egg; these consist of a finely granular protoplasm, which sends out a number of filamentar, and in some cases very long, processes, while in their centre there is a vesi-

* Bull. Mus. Comp. Zool. Cambridge, U.S.A., viii. (1881) pp. 257–74 (2 pls.).
† Zeitschr. f. wiss. Zool., xxxv. (1881) pp. 440–60 (1 pl.).

cular nucleus together with several nucleoli, and they are to be distinguished from a set of smaller cells.

A careful account is given of the succeeding stages, and a comparison of them with the descriptions of other observers as to what obtains in allied forms; and the author points out that, though there is an essential difference between the mode of development of the marine and of the fresh-water Amphipods, the results show that there is in them all an intra-vitelline or superficial segmentation. The ova of the Orchestidæ exhibit an intermediate stage towards the extra-vitelline or discoidal segmentation.

Passing to the "kugelformige" organ, Uljanin shows that it is a local invagination of the ectoderm, the cells of which shed out a cuticle which is in connection with that developed from the surface of the embryo; it is altogether comparable to the shell-gland of the Mollusca, and, this being certain, the question arises as to whether there is in the Crustacean anything homologous to the shell. Now, the shell of the Mollusca is a product of the secretion of the so-called mantle, which is nothing else than a local thickening of the ectoderm. In the Arthropod we do not find this; and this being so, we cannot homologise the cuticular investment of the Arthropod-embryo with the shell of the Mollusca. The presence of this shell-gland is a distinct proof of the common origin of the two groups; but, beyond this, there is little to be said. We may suppose that the common form consisted of a number of equivalent metameres, had a dorsal internal shell, a dorsal vessel, an enteric canal which opened at the hinder end of the body, an œsophageal nerve-ring, and a ventral ganglionic chain. The form now standing nearest to this hypothetical ancestor is the Chiton.

A short account of the development of the endoderm is given, which the author shows to have its origin from the cells of the "kugelformige" organ, or in other words, from cells of ectodermal origin, which have wandered into the yolk. This is clearly a secondary result. The mesoderm, as in all other Crustacea, is developed by the cleavage of the blastoderm.

Limulus polyphemus.*—A paper "On the Anatomy, Histology, and Embryology of *Limulus polyphemus*," by Dr. A. S. Packard, jun., may be regarded as a continuation of the author's former series on the development of the king-crab.† He discusses fully the question of the affinities of that puzzling animal, and combating the position of those zoologists who connect *Limulus* with the Arachnida, he sums up the facts which point to the crustacean nature of *Limulus* as follows:—

(1) The nature of the branchiæ, those of *Limulus* being developed in numerous plates overlapping each other on the second abdominal limbs (those of the Eutrypterida being, according to H. Woodward, attached side by side like the teeth of a rake), while the mode of respiration is truly crustacean; (2) the resemblance of the cephalothorax of *Limulus* to that of *Apus*; (3) the general resemblance of the

* Anniv. Mem. Boston Soc. Nat. Hist. 1880, 45 pp. (7 pls.).
† See this Journal, iii. (1880) p. 947.

gnathopods to the feet of Nauplius or larva of the Cirrhipedia and Copepoda; (4) the digestive tract is homologous throughout with that of Crustacea, particularly the Decapoda, there being no urinary tubes as in Tracheata; (5) the heart is on the Crustacean type as much as on the Tracheate type, and the internal reproductive organs (ovaries and testes) open externally, at the base of and in the limbs, much as in Crustacea.

The paper is illustrated by seven plates showing the circulation of *Limulus*, sections of the adult and of embryos, and details of the structure of the eyes, with comparison of these with those of Trilobites, with which group the author, as in his first memoir, allies the Merostomata.

**Stomatorhiza of Sacculina carcini.***—M. S. Jourdain finds that these structures form delicate tubes with milk-white contents, which ramify largely and irregularly. They form a very complex network around the digestive tube, and are also found in the middle of the liver; they extend on to the genital gland, and, insinuating themselves into the muscles of the sternal region, make their way to the extremities of the limbs of their hosts. That they never touch the heart, the gills, or the central nervous system is probably the reason why the host apparently retains its general health. They are distinguished by their opaline white colour, even in the midst of the tissues which they infest. Their sheath is hyaline and structureless, very firm, and apparently formed of chitin. Near the extremity of these processes there is developed a kind of sucker, which has at its centre a slightly depressed orifice, corresponding to the cavity of a flask-shaped body, which is, perhaps, the seat of a secretion which renders absorbable the anatomical elements on which the creature is parasitic.

The Sacculinæ are themselves the host of a species of *Saccharomyces*, which destroys it, and which is quite distinct from the *Mycoderma vini* or *S. cerevisiæ*. Each of the poles of the long axis of its cells gives off a myceliform prolongation. These ferment-cells frequently have psorosperms associated with them.

### Vermes.

**Organization of Sternaspis scutata.**†—In a second communication, M. Max Rietsch deals with the vascular system and generative organs of this worm.

As to the former, he finds that the dorsal vessel follows the coils of the stomach; the ventral vessel has numerous roots connected with the pharynx and anterior setæ; it runs parallel to the nerve-cord, to which it gives off various branches, as well as to the segmental organs. Near the middle of the body it gives rise to a vessel which accompanies the posterior portion of the intestine, and to two others which give rise to the four genital vessels. The whole of the intestine is provided with a very rich system of blood-sinuses, connected with the dorsal and with the anterior portion of the ventral vessel.

The genital organs have the same form in both sexes. The two

* Comptes Rendus, xcii. (1881) pp. 1352–4. † Ibid., p. 1066–9.

oviducts or sperm-ducts are directed towards the middle line, where they unite and come into contact with the ventral vessel. From the point of union there arise the four lobes of the ovary or testicle. The ova are developed on the wall of the genital vessel, and at the expense of the epithelial cells which form this wall.

In front of the oviducts and imbedded in the folds of the œsophagus there are two large segmental organs, of a brown colour, and with delicate lobes; they are irregularly lobate in form, and are provided with a duct which opens to the exterior by an extremely minute pore. No vibratile infundibula were detected in connection with these organs.

The eggs are about ·15 mm. in diameter; the spermatozooids are from ·10 to ·085 mm. long, and the head is about one-sixth the length of the whole. Segmentation is complete, and commences about five hours after impregnation; the two spheres are unequal from the first, and a planula is formed by epiboly. The earliest seen larvæ had no mouth or anus, were covered with long cilia, except at their posterior region, and had an anterior tuft of long cilia.

The author hopes to be able to publish a complete monograph of this creature.

**Syngamus trachealis of Pheasants.*** — M. P. Mégnin has examined this Nematode, the cause of the disease known as the 'gapes,' and after a diagnosis of the genus and of the species gives a general anatomical account of the parasite.

The excretory system appears to be somewhat difficult to make out, but in one example the author detected an oblique canal opening in the integument a little below the nerve-collar, and arising from a glandular mass. A true salivary gland is described as running along the œsophagus, and as being lined by ovoid cells, with two nuclei. After an account of the generative organs the author proceeds to an account of the development of these forms. The nymph-stage is believed to be very short, and to be passed through in the air-sacs of the host. This conclusion is based on the following facts: (1) The larvæ are only born and become vigorous in a damp medium, and at an elevated temperature. (2) In young pheasants which have died of the disease, a large number of eggs have been found in the mucus of the œsophagus, but these eggs were empty. (3) In the serum of the walls of the air-sacs, and above all in that of those cavities which are in connection with the duodenal portion of the intestine, very active larvæ of *Syngamus* have been found. (4) In the peri-tracheal cellular tissue a young red-coloured *Syngamus* was found. The number of ova found in one pheasant are to be numbered by thousands, but a very large proportion die during development. The author concludes with some practical hints for the destruction of these parasites.

**Excretory Organs of Trematoda and Cestoda.**†—In a further communication, M. J. Fraipont ‡ describes the organs of *Distomum*

* Bull. Soc. Zool. France, v. (1881) pp. 121–42 (2 pls.).
† Arch. de Biol., ii. (1881) pp. 1–40 (2 pls.).
‡ See this Journal, *ante*, p. 37.

*divergens*, in which there is a large terminal vesicle in the median dorsal line, which extends from the hinder extremity of the body to near the ventral sucker; into this sac two trunks open in a somewhat peculiar manner, for they penetrate some way into it, preserving their original diameter; the number of ciliated infundibula is small. The organs of *Scolex trygonis pastinaceæ* are next described. In young forms of *Tænia echinococcus* there is a complicated system of fine canaliculi, which have their origin in the small ciliated infundibula.

The author then proceeds to some general considerations. He now finds some important deviations from the primitive type to which he first referred * this system of organs; secondary foramina may be developed and the terminal vesicle may disappear. To understand these phenomena, we must first have a clear idea as to the constitution of a Cestoid worm. The author is of opinion that we have not to do with a true colony; he looks upon a proglottis as forming a group of organs, and as comparable to the spermatophore-arm of a Cephalopod. From the "point of view of individuality," the Cestode is the equivalent of a Trematode, more altered in consequence of its parasitic habit, considerably elongated, and more complicated in consequence of the repetition of the sexual organs and the tendency to metamerism. Primitively, the excretory apparatus of an unsegmented Cestode communicated with the exterior, just as does that of a Trematode, by a single posterior caudal foramen. But when the body became elongated, a moment appeared at which the terminal vesicle was not sufficient for its economy; then appeared the *foramina secundaria.* With greater development these pores became symmetrically and regularly distributed over the body. As they became more important, the duties of the terminal vesicle diminished, and disuse led to atrophy. But though these organs became "segmental," they do not seem to be the homologues of the "segmental organs" of the higher Vermes.

After a reference to the studies of preceding observers, and more especially of Hatschek, whose essays have been fully analysed in this Journal, M. Fraipont asks whether we are justified in regarding the segmental organs of a Cestode as the homologues of those of an Oligochæte. He answers the question in the negative, for he finds that the organ of the Cestode is differentiated from the head-kidney, while in the Oligochæte it is probably a part of the longitudinal canal; so that in them it is an organ which has no homologue either in the Rotifer or in the Flat-worm. He then deals with the case of the Gephyrea, where the head-kidney persists for a time only, and passes on to the trochophore-larva of the Mollusca. The author concludes this part of his paper with the following words:—"*En résumé*, we admit that the excretory apparatus of the Trematoda and Cestoda is the homologue of that of the Rhabdocœla, Nemertinea, and Rotifera, as well as of the head-kidney of the Annelida, Gephyrea, and Mollusca. The Trochozoon-theory of Hatschek appears to us

* See this Journal, iii. (1880) p. 802.

to be well established as applied to the development of the urinary apparatus of the Platodes and Rotifera, for all Annelids, including the Gephyrea, for the Bryozoa, Mollusca, and Brachiopoda; even, too, for the Nematodes and Cephalotricha, and, perhaps, also for the Arthropoda."

The author then proceeds to his ideas on the body-cavity, and enters into an elaborate account of the speculations of Ray-Lankester (see next note), which he hardly represents accurately. He concludes that the system of the canals of the excretory apparatus of the Trematoda and Cestoda does not constitute a true blood-lymph system at all, but that it is an apparatus with the same definite objects as the segmental organs of the Annelids. On the other hand, the blood-lymph system of these worms is solely formed by intercellular spaces, of lacunæ, and of interstitial plasmatic lacunæ.

**Cœlom and Nephridia of Platyhelmia.***—Professor Ray-Lankester, in reference to the notice as to his views which M. Fraipont has made in the previous paper, remarks that Haeckel had criticized the doctrine that part of the fine canal system in the Platyhelmia represented the cœlom of Cœlomata, by justly urging that "we did not possess any knowledge of the development of the canal system in Platyhelmia which warranted the assumption that any part of it was the representative of the cœlom of other animals." The discovery by Bütschli, and the extension of his observations by M. Fraipont, as to the existence of the terminal ciliated bodies of the nephridia, are of importance as enabling us now to say, "Here nephridium ends, and here cœlom begins." Professor Lankester points out that what he has believed to be the case—viz. that the ultimate ramifications of the canal-system were intercellular, and, like the sinus-system of a mollusc, equivalent to a cœlom, is just what Bütschli and Fraipont have proved to be the fact.

**Anatomy of Distomum clavatum.**†—Dr. E. Jourdan has a note on this form, which is remarkable among its allies from the fact that it lives freely and is not parasitic; and the chief aim of this notice is to demonstrate that, notwithstanding the doubts of Dujardin, this form is truly a Trematode. The essential characters of the species are the size of the abdominal sucker, the deep transverse folds which are developed on the posterior region, and the canal-like depression which intervenes between the buccal and the abdominal sucker. These specific characteristics distinguish as much the free-living forms as those which were found in the intestine of the tunny. The author enters into a short account of the different organs, the characters of which appear to justify him in his belief as to the Trematode affinities of this sometimes free form.

**Development of Tricuspidaria nodulosa.**‡—The epidemic among the perches of the Seine has given M. P. Mégnin an opportunity of studying this parasite. The livers of all the perch examined were

* Zool. Anzeig., iv. (1881) pp. 308–10.
† Rev. Sci. Nat., ii. (1881) pp. 438–9 (2 pls.).
‡ Comptes Rendus, xcii. (1881) pp. 294–6.

filled with cysts, which varied in size from that of a pin's head to that of a pea. When the inner face of the cyst is examined, it is found to be covered with small buds, bi-, tri-, or quadrigeminate. At first sessile and hemispherical, they become spherical and provided with a pedicle, and at last take on a cylindrical form; they then detach themselves from the wall of the cysticercus, and continue to elongate. These forms are not sexually mature, but such forms are often found in the intestines of the same perch. In some examples in which remains only of the cysts were observable, the author found the parasites making their way through the parenchyma of the liver, or in the ducts of that organ. We have, then, here another example of the two stages in the life-history of a Tænioid parasite, represented in the body of one and the same host.

**Eye of Planarians.***—Professor R. Hertwig finds that the nervous system is very primitive in character, and is but slightly separated off from the surrounding tissue; in the eye, it is possible to distinguish a black pigmented and a clear colourless portion. The former lies along the animal's axis; the latter is just below the epithelium, and is only separated from it by the basal membrane. The pigmented portion, again, consists of two parts, a transparent nucleus (vitreous body) and a superficial layer of surrounding pigment-cells, which are only wanting at the diaphragm-like point at which the retina or colourless part is connected with the rest. The cylindrical fibres of the vitreous body are arranged parallel to one another, the nucleated ends being nearest the pigment. The retina is only formed of optic cells, which are continued at one end into a nerve-fibre and at the other into a rod-like process. The fibres of the optic nerve traverse the retina in a very irregular manner, so that there is no regular arrangement of the optic cells.

## Echinodermata.

**Echinoderms from the North Sea.**†—Messrs. Danielssen and Koren describe a new genus of the family Asterinidæ, to which they give the name of *Tylaster* (*T. Willei*), in which the dorsal marginal plates are rudimentary; and another which they call *Poraniomorpha* (*P. rosea*). They also describe as new species *Asterias spitsbergensis* and *Solaster glacialis; Asterina tumida* var. *tuberculata* is also described and figured; the species *A. tumida* was first placed in the genus *Solaster* by its describer Stuxberg.

**Echinodermata of the Straits of Magellan.**‡—Professor Jeffrey Bell describes four new species of the genus *Asterias—A. Brandti*, *A. alba*, *A. obtusispinosa*, and *A. neglecta;* a species of *Pentagonaster* (*P. paxillosus*), hitherto recorded only from Australia, would seem to be a member of the South American fauna. *Cycethra* is the name of a new genus, "which, though generally goniasterid in character, seems,

* Jen. Zeitschr. f. Naturwiss., xiv. (1881) Suppl. Heft, pp. 55–6.
† Nyt Mag. f. Naturvid., xxvi. (1881) pp. 177–95 (2 pls.).
‡ Proc. Zool. Soc. Lond., 1881, pp. 87–101 (2 pls.).

and that more especially at first sight, to present a combination of characters." Only one new Ophiurid—*Ophioscolex Coppingeri*, and one new Astrophytid—*A. Lymani*—are described. Specimens were obtained of that *Cuvieria antarctica* which has so striking a resemblance to the *Psolus phantapus* (*C. Fabricii*) of the Arctic Seas. A new species of *Strongylocentrotus* (*S. bullatus*) of large size is described, and an account is given in full of a smaller form, which, the author says, he was for long inclined to regard as another species; but a "long and close study of other members of the genus has convinced me that the form of the arc of pores may vary very considerably during growth."

**Nervous System of the Ophiuroidea.***—M. N. Apostolidès points out that the perineural space in which the nerve-ring is situated forms a circular canal, which is bounded by the wall of the second discoid ossicle, and by two membranes which, starting from the point where the œsophagus passes into the stomach, extend above and below it, and become connected with the ossicle just mentioned. In this space the nerve-ring is set vertically while its rays are horizontal. The water-vascular ring lies outside the nerve-ring, and, as its branches pass out by the same orifices as the nervous rays, it follows that there is always a very close connection between the two sets. Where the nerve and the ambulacral vessel are folded back, the perineural cavity communicates with the other spaces of the body. This explains how Teuscher's injection made its way around the nervous system. Histologically the nervous band consists of two very distinct tissues, one composed of a mass of cells of a brown colour and with large nuclei. These cells are comparable to the pigment-cells of the Vertebrata. The rest of the band consists of extremely fine fibres, among which a high magnification reveals the presence of bipolar cells; this is the only part of the band which is really nervous; it only, however, constitutes a small portion of the whole. There are no special ganglionic enlargements on it, and when a swelling is developed, it is at the expense of the non-nervous portion. The nerve-rays give off on each side two branches, the superior of which is directed towards the first tentacle. When it has got near this it bifurcates; the two branches of the bifurcation surround the end of the tentacle, and then they anastomose with the opposite side, so as to form a complete circle. No distinct nerve-branches could be made out on the wall of the tentacle. The lower branches are directed to the muscles between the angles of the mouth.

**Viviparous Chirodota.**†—Professor H. Ludwig has published his promised essay on this interesting Brazilian form. The single adult was 18 mm. long and 4·5 mm. thick, cylindrical in form, and rounded off at either end. The surface is covered, except along the rays, by opaque tubercles, in each of which were found more than one hundred of the characteristic "wheel-organs" of the genus; and, in addition to these, there were, in smaller number, calcareous rods thickened at

* Comptes Rendus, xcii. (1881) pp. 1424–6.
† Arch. de Biol., ii. (1881) pp. 41–58 (1 pl.).

their ends, and slightly swollen in the middle. Twelve pinnate tentacles were so distributed as to lie, three for each of the lateral dorsal interradii, and two for each of the other interradii. The calcareous ring consists of three joints, and into the radial pieces there are inserted five short retractor muscles.

The genital tubes appear to give rise to both ova and spermatozoa, the latter being developed in their blind ends and lateral branches.

Lying freely in the cœlom there were sixteen young, all at about the same stage in development; the body-wall was so transparent that the intestine could be seen. There were five tentacles at the anterior end, each of which had two small depressions (the future pinnate lobules) at its tip. In the body-wall there are to be seen groups of developing or developed calcareous wheels, which at first have the form of a six-rayed star, each ray of which has at its free end a process on either side; later on the two neighbouring processes unite and so form the circumference of the wheel.

For further investigation, the specimens were either clarified as a whole or cut into sections. It was then seen that, in addition to the five tentacles 3 mm. in length, there were two others 1 mm. long, and that these lay more internally. The five larger ones appear to double, and so the somewhat remarkable number of twelve is arrived at. No circular, but only longitudinal muscular fibres could be made out in the walls of the tentacles. A small rounded Polian vesicle depended ventrally from the water-vascular ring, and dorsally there arose the interesting stone-canal, which takes a curved course to the body-wall.

Here it is continuous with a backwardly directed canal which extends throughout the whole length of the body, and lies between the ectodermal and endodermal layers. This canal ends in a blind terminal piece. It is well known that in most cases the stone-canal loses, in the adult Holothurian, all connection with the exterior, although in some cases, as Koren and Danielssen have lately shown, there is such a connection throughout the whole life. Dr. Ludwig looks upon the arrangement here described as being an intermediate stage.

The nerve-ring and its radial nerves consist of an outer cellular and an inner fibrous ring; outside the nerve-ring there is a special cavity, which becomes considerably enlarged between the tentacles, and contains mesoderm-cell-like elements. This may be a remnant of the cleavage cavity. Small vesicles are found by pairs in connection with each of the radial nerves, and are regarded by the author as comparable to the so-called auditory vesicles of other Synaptids.

The paper concludes with the description of two new species from Brazil—*Thyonidium parvum* and *Synapta Benedeni;* the latter has the general appearance of *S. digitata*, but in the form of its anchoring spicules it seems to come nearer to *S. pseudodigitata*.

## Cœlenterata.

**Organization and Classification of the Acraspedota.***—In this communication, which may, we think, be taken as a Prodrome of his second volume on the Medusæ, Professor Haeckel deals with this division of the jelly-fishes. It is one which contains the higher forms, and is in no way connected by any intermediate representatives with the Craspedota. The remarkable resemblance which obtains between the two divisions is due not to true phylogenetic relationship or inheritance, but to a convergence of forms or an adaptation to similar conditions of existence. The Acraspedota and the Craspedota have, according to Haeckel, arisen from two different groups of Polyps. The former, without exception, possess gastric filaments and endodermal gonads, and have no true velum. They arise from the Scypho-polyps, or forms in which there were four interradial gastric projections (tæniolæ). On the other hand, the Craspedota have no true gastric filaments, but have a true velum, and ectodermal gonads; they arise from the Hydroid Polyps, in which there are no interradial tæniolæ. In a phylogenetic table we see that the Hydraria (*Hydra*) have given rise to the Scyphopolypi (*Scyphostoma*), and the Hydropolypi (*Hydrostoma*), and that these two phyla have always remained altogether distinct from one another.

The Discomedusæ are often regarded as representing the Acraspedota; but this should not be so. There are three other orders also—the Stauromedusæ, Peromedusæ, and Cubomedusæ, which three may be united into the sub-legion Tesseroniæ, as against the second sub-legion of Ephyroniæ (= Discomedusæ). The Tesseridæ may be regarded as the stem-group of all the Acraspedota. Of these, the simplest and oldest is *Tessera*, which in all essential details resembles a free-swimming *Scyphostoma* polyp. It has no marginal bodies, but eight simple tentacles in their place. The closely allied *Tesserantha* has, in addition, eight adradial tentacles, and a number of gastric filaments.

The Lucernaridæ are closely allied to these "primitive and most instructive" Tesserida; they agree with them in all essential details, and are only distinguished by the fact that the eight principal tentacles are converted into marginal anchors or are lost, while the edge of the mantle is produced into eight hollow marginal lobes or arms, each of which carries a tuft of hollow tentacles.

These two families form the orders of the Stauromedusæ, which are distinguished from the other three by retaining their primitive simplicity, or by the absence of any special sensory organs. The other three have all sensory (marginal) bodies or *rhopalia*, which have been developed from the principal tentacles of *Tessera*, and consist of a special union of an auditory and an optic organ. The Peromedusæ have four interradial rhopalia, the Cubomedusæ have four perradial, and the Discomedusæ have four perradial and four interradial (with, in many cases, other accessory organs).

All three orders may be easily derived from *Tessera*; *Pericolpa*

* Jen. Zeitschr. f. Naturwiss., xiv. (1881) Suppl. Heft, pp. 20–9.

(the stem-form of the Peromedusæ) has the four interradial tentacles converted into rhopalia; *Procharagma* (the stem-form of the Cubomedusæ) has the four perradial tentacles so converted; while in *Ephyra* (the stem-form of the Discomedusæ) all eight are so converted.

The first order is broken up into the Pericolpidæ and the Periphyllidæ; the second into the Charabydeidæ and the Chirodropidæ; and the third into the Carmostomæ, Semostomæ, and Rhizostomæ. The first two, with the Stauromedusæ, form the sub-legion Tesseroniæ, in which the umbrella is hollowed out, conical or quadrilaterally pyramidal, the gonads developed centrifugally, the subumbral wall provided with four wide gastric pouches, and the sensory organs none or four. In the Ephyroniæ the umbrella is flattened and discoid, the gonads developed centripetally, and the sensory organs at least eight in number. They all pass through an *Ephyra*, as the others do through a *Tessera* form.

**The Discomedusæ.*** — In a further communication, Professor Haeckel gives the following arrangement of the sub-orders of this division:—

1. *Carmostomæ.*—Mouth-tube simple, no buccal arms; central mouth simple, quadrilateral; radial pouches broad, no circular canals; four or eight gonads; tentacles solid, generally short. Here we find the families Ephyridæ and Linergidæ.

2. *Semostomæ.*—Mouth-tube divided into four perradial folded arms; central mouth simple; radial pouches broad and without a circular canal, or narrow and with one; four gonads; tentacles hollow, generally long. Here we have the Pelagidæ, Cyaneidæ, Flosculidæ, and Ulmaridæ.

3. *Rhizostomæ.*—Mouth-tube replaced by eight adradial arms with numerous sucking mouths; central mouth obliterated; radial canals narrow, always branched; a circular canal; four gonads; no tentacles. This suborder includes the families Toremnidæ, Pilemidæ, Versuridæ, and Crambessidæ.

The author gives a phylogenetic table to show the genetic relations of these different groups.

## Porifera.

**Observations on Sponges.**†—F. E. Schulze's tenth communication is dedicated to *Corticium candelabrum* O. Schmidt.

After a short history of the genus and of the seven species now referred to it, the author gives a general account of the species he has especially studied. With regard to histological details, he points out that they are easier to study than in most sponges, on account of the cartilaginous consistency of its hyaline substance. In many, and especially in young examples, it is quite easy to make out a unilaminate layer of pavement epithelium investing the whole of the free surface of the body. The rather high and often cubical cells

* Loc. cit., pp. 51–4.
† Zeitschr. f. wiss. Zool., xxxv. (1881) pp. 410–31 (1 pl.).

are sharply marked off from one another; a cilium could not be detected; but in close connection with the cell there was found the cell-layer which invests the afferent canals. This does not differ essentially from the superficial investing layer, and it is only in the finest terminal canals that the cells diminish in height. The endoderm, just as in *Halisarca lobularis* and *Plakina*, has the whole of its wall lined by the collar-cells, although these are excessively small. In the mesoderm we can distinguish hyaline and opaque substances, the difference between which does not merely depend on the presence of ciliated chambers in the latter, as much as on the possession by the hyaline substance of small, highly refractive granules. The siliceous bodies are found in the mesoderm alone, but they vary very much in the extent to which they are developed. The author thinks that he has been able to make out a pretty continuous series between the normal quadriradiate forms and the complex candelabra which distinguish this species, and he works out some points in their homological relations. In an example from Cebu, Schulze found, at some slight distance from the surface, a very small, and apparently lately formed, siliceous spicule, imbedded in a round pigmented cell. This observation leads him to believe that the spicule was really developed within the mesoderm, and to give in his adhesion to the doctrine of various spongiologists that the rudiments of the spicules arise in cells. *C. candelabrum* is hermaphrodite, and though this has afforded good opportunity for study, the author has not been able to make out any definite arrangement or grouping of the genital products. The sperm-spheres do not appear to differ essentially from those found in other sponges. The ova are irregularly rounded and so richly filled with yolk-granules as to completely obscure the pretty large nucleus and nucleolus. Cleavage appears to be complete, and the blastula, when formed, exhibits a single layer of delicate cylindrical cells.

**Sexual Characters of Halisarca lobularis.***—Dr. M. Braun, in reference to the statement of F. E. Schulze that this sponge is diœcious, and the contrary opinions of Eimer, Haeckel, and others that it is hermaphrodite, states that he has found by sections that the specimens he examined at Trieste had the sexes united. At the same time, the author is not of opinion that Schulze was not justified in his conclusion; he thinks it possible that, in this very low class of animals, the sexual conditions of a species may not be yet fixed. In *Tubularia mesembryanthemum*, no doubt, hermaphrodite and diœcious arrangements are respectively to be observed at different periods of the year. Schulze says of *H. lobularis* that the sperm is produced from the middle of July to the beginning of August, and ova from the end of July to the beginning of September; the sperm are, therefore, produced earlier than the ova. Cases of this kind are, as the writer very justly observes, of the greatest importance in the study of the difficult question of the differentiation of the sexes.

* Zool. Anzeig, iv. (1881) pp. 232–4.

**Leucandra aspera and the Canal System of Sponges.***—G. C. J. Vosmaer, in studying the *Leucones*, has come to somewhat different conclusions from those of Haeckel and Keller with regard to their canal system. His conclusions are based chiefly on the above-mentioned species. With regard to its *canal system*, it may be seen with a lens that the outer side of the sponge is beset with numerous small openings, while those of the gastral face are considerably fewer but larger. Sections made of alcoholic specimens (after decalcification with crude wood-vinegar) in the horizontal, vertical, and tangential directions show that the inhalent orifices lead into comparatively wide canals, which penetrate the body-wall either directly, or by branching, or by anastomosing together; the gastral openings, too, lead into wide canals, and the two sets of canals are connected by the ciliated chambers. These chambers open directly into the wide excretory canals, but communicate with the inhalent tubes only by small pores ("chamber pores"). The ciliated chambers lie radially around the excretory canals, mostly close together. This arrangement of the canal system agrees with that of *Aplysilla*, *Spongelia*, and other forms. Three regions may be distinguished in the wall—an outer, spicular one, containing triradiate and linear spicules; a median one, with the ciliated chambers; and an inner spicular one, containing chiefly tri- and quadri-radiate forms. As Schmidt and Keller have stated, the quadriradiates sometimes disappear altogether.

*Histology.*—Vosmaer finds three histologically distinct body-layers, but withholds his judgment as to their relation to embryonic conditions. The first layer (*a*) is the tabular epithelium, which in *L. aspera* covers all the surfaces, internal and external, with the exception of that of the ciliated chambers, and extends over the bases of the large projecting linear spicules. It exhibits practically the same characters in all parts, though in the so-called entoderm the cells are somewhat smaller than elsewhere. The cells are large, flat, sometimes bearing long processes, quadrangular or polygonal in outline, with a coarsely granular protoplasm, which is only slightly coloured by hæmatoxylin; they have a finely granular, round nucleus, with one or more nucleoli. It is probable, but not certain, that a cuticle covers and unites the cells; they are separated by clear spaces. (*b*) The second layer is formed by the connective tissue and its products, derived most probably from the mesoderm; that it is of the nature of connective tissue, and not a Syncytium, in which the nuclei are the only distinctive traces left of the original cells, now fused together, seems to the author more in accordance with the fact of its composition of fusiform or stellate cells with distinct nuclei, with its often firm consistency, with the results of Metschnikoff's experiments with acids, with the slight capability for becoming stained which the ground-substance possesses, and finally, with the generally admitted connective-tissue nature of the closely similar tissues, embryonic connective tissue, Medusan gelatinous tissue, Cephalopod cartilage, the mantle of Tunicates, &c. In this particular sponge, this layer consists of a completely hyaline ground-substance inter-

* Tijd. Nederland. Dierk. Vereen., v. (1881) pp. 144–64 (2 pls.).

spersed with small, chiefly fusiform cells which Haeckel seems to have taken for nuclei, having remarked on the comparatively slight readiness with which they become stained. Some of the cells possess large, clear spaces, which are perhaps vacuoles; the amœboid cells occurring amongst the others are true ova; spermatozoa have been, with some probability, detected in the form of agglomerated masses. Thus it is probable that both kinds of sexual products proceed from the mesoderm. The laminæ composing the spicula are irregular in thickness at different parts, contrary to Haeckel's assertion; they possess a distinct sheath, in which, however, no nuclei or structure were detected. (*c*) The ciliated epithelium constitutes the third layer, and includes only the collar-cells of the chambers; the collars of these are chiefly narrow and tubular, and appear, by the frequently compressed and contracted state in which they are found, to be specially sensitive.

*Affinity of the Leucones with the other Calcisponges.*—The *Ascones* appear to give rise to the *Sycones*, as Haeckel has said, by invagination of the gastral layer with its collar-cells at various points, forming small radial tubes; but a study of the relations of the quadriradiate spicula of the radial tubes seems to show that it is the gastral (i. e. internal) opening of the tube which is homologous with the osculum of *Ascon*. But it seems probable, not that each radial tube, but that the entire *Sycon* is the equivalent of the primitive *Ascon;* and further, that the *Sycon* is not, by virtue of its intercanals and other peculiarities, so distinct a type as Haeckel infers, but may be connected with the *Leucones*. Thus the intercanals of the *Sycones* are probably simply the spaces left between the invaginated radial tubes, and their variations in size depend on the extent to which those tubes are laterally united with one another; thus it is probable that the intercanals represent the *Ascon*-pores or "pit-canals" of Haeckel. The *Leucon* canal system appears to arise from that of the *Sycones* by the formation of lateral cæca by the radial tubes, which become bound together by a strong connective-tissue development, and the entoderm or collar-cell layer becomes limited to small portions of the original invagination. Thus (1) the radial tubes are imperfectly homologous with ciliated chambers. (2) *Sycon* is derived from *Ascon*, and may be modified to form *Leucon*. (3) A simple *Leucon* is the homologue of a simple *Sycon*, and therefore with an *Ascon;* each forming one *person*, whose morphological centre is that space in each which is lined by the entoderm cells.

Point (1) is proved by the similar origin of the radial tubes and ciliated chambers of *Leucon*, and supported by the fact that in some cases even the former send out lateral cæca.

The canal system of other—i. e. non-calcareous—sponges may be derived from the *Leucon*-type by the development of its ectodermal invaginations into a system of fine canals, each ending in a ciliated chamber. In fine, four main types of canal system must be assumed to exist in the sponges.

1. *Ascon*-type, the *primary* form; the part which bears the collar-cells opens directly to the exterior.

2. *Sycon*-type, the *secondary* form; the part which bears the collar-cells opens into the gastral cavity, and this alone opens to the exterior.

3. The *tertiary* form is represented by *Aplysilla*, *Spongelia*, *Halisarca Dujardini*, *Leucandra aspera*, most *Renierida*, some *Suberitida*, and probably the *Hexactinellida*. *Plakina* is on the border of this group. The part which bears the collar-cells opens directly into wide canals, and these in turn into broader vessels, or into the gastral cavity, which opens directly to the exterior.

4. The *quaternary*, the most differentiated form, finds numerous representatives among the horny and siliceous sponges. Lowest come *Aplysina*, *Euspongia*, *Cacospongia*, *Hircinia*, *Oligoceras*, *Plakortis*, *Plakinastrella*; higher stand *Halisarca lobularis* (which, by reason of its great differences from *H. Dujardini*, Vosmaer proposes to distinguish generically as *Oscaria*), *Chondrosia*, *Chondrilla*, *Corticium candelabrum*. The part which bears the collar-cells does not open directly into wide excretory canals, but by the medium of tubes, usually very fine. The actual point of entrance of the inhalent canal into the ciliated chamber is termed the *pore*, in preference to usual application of this term to the opening at the surface of the sponge.

**New Fresh-water Sponges.***—Mr. E. Potts records several new species of *Spongillæ* which give reason to believe that the order Spongida has many more fresh-water representatives than has been generally supposed.

The first, *Spongilla tenosperma*, exhibits features so exceptional as almost to claim for it generic distinction. It was found in a small stream near Philadelphia creeping upon and around *Anacharis* and willow roots, matting them together, and thus forming loose irregular masses several inches in diameter; colour yellowish, light or dark green, according to exposure to the light. Sphærulæ globular, light yellow or brown, rather numerous amongst the roots and spicula; covered with long birotulate spicula radially arranged; foramen elongated into a tube flaring at its extremity and dividing into 2–5 tapering, slender, curling or twisted tendrils, believed to be as much as half an inch in length. The sarcode decomposes early in the season, and most of the skeleton spicula are then washed away; but these tendrils hold the mass of sphærulæ attached to the roots, &c., above mentioned, awaiting the spring germination.

In the same place a variety was found resembling *S. lacustris* in its general appearance and in the shape of its skeleton and dermal spiculæ, but differing in that the seed-like bodies or sphærulæ are entirely smooth, showing no incrustation of curved spined spicula as in the European species.

A very slender green species was also found creeping along stems of *Sphagnum*, &c., in a swamp near Absecom, N.J. As it appeared to be entirely without spined spicula of either class, the name proposed for it is *S. aspinosa*.

In the Adirondack lakes a beautiful species, believed to be iden-

* Proc. Acad. Nat. Sci. Phila., 1880, pp. 330–1 and 356–7.

tical with *S. stagnalis* Dawson, was obtained. Another lacustrine form, which is not quite *S. lacustris*, was brought from the lake near Catskill Mountain House. Its status has not been fully determined.

From the cellar of an old ruin at Lehigh Gap, Pennsylvania, four species were obtained which appeared to be new. These were all thin, creeping or encrusting sponges, three of them of the birotulate type, briefly described as follows:—*S. argyrosperma.*—Seed-body or sphærulæ large, silver-white, densely covered with radial spiculæ, the shafts of which are long, stout, with numerous long spines, straight or curved; the rotulæ at each end being replaced by 1–4 strong recurved hooks.

*S. repens.*—Found creeping over the stems and leaves of *Potamogeton;* sphærulæ also closely covered with spicula, shorter and more slender than those of the preceding species; their shafts nearly smooth, the rays of the rotulæ, six, eight, or more, uniformly incurved like the ribs of an umbrella.

*S. astrosperma.*—The sphærulæ have the appearance of being much smaller than in either of the former species, which is probably due to the fact that the birotulate spicula surrounding the real capsules are very short; the length of the shaft being less than the diameter of the rays. They are rather sparsely scattered over the surface of the nearly transparent sphere, suggesting the name star-seeded.

The remaining form is considered a variety of *S. fragilis*, and called *minuta;* sphærulæ much smaller than in the type species, the dermal and superincumbent spicula terminated by sharp points, while in the other they are universally truncate or rounded.

Mr. H. Mills also records * a variety of *Spongilla lacustris* found in Niagara River.

**History and Classification of Spongilla.**†—Mr. H. J. Carter gives a most useful *résumé* of the fresh-water sponges, commencing with the first public notice of them by L. Plukenet in 1696, and including the researches of W. Dybowsky, which we noticed *ante*, p. 256. The Bibliography includes 32 papers.

The fresh-water sponges are, according to Mr. Carter, the fifth family (Potamospongidæ) of the sixth order (Holoraphidota) of the Spongida, and the classification which he proposes of the group Spongillina is based not on the form of the skeleton-spicule, which is almost always more or less alike in all, but chiefly on the spicules of the seed-like reproductive organs or statoblasts, the possession of which at present constitutes a sharp line of demarcation between the marine and fresh-water sponges. Of the genera into which the Spongillina are divided (formerly all treated as belonging to the one genus *Spongilla*), *Spongilla* has ten species (three n. sp.), *Meyenia* eight (one n. sp.), *Tubella* four (one n. sp.), *Parmula* two, and *Uruguaya* (n. gen. prov.) one. A statoblast is at present unknown in the latter genus.

* Amer. Journ. Micr., vi. (1881) pp. 30–1.
† Ann. and Mag. Nat. Hist., vii. (1881) pp. 77–107, 263 (2 pls.).

With the exception of Europe the localities in which fresh-water sponges have been found are few and far between, and no notice has been published of their occurrence in Africa. It may be fairly inferred that a great many more species will be discovered there as well as elsewhere, and Mr. Carter considers that we are only on the threshold of our knowledge of the extent and varieties of the fresh-water sponges, so vast are the fresh-water areas which have not been explored.

**Sponge Spicules in Chert.***—Professor W. J. Sollas confirms his detection of sponge-spicules in chert from the carboniferous limestone (Ireland). In some slides which he examined the chief determinable constituents were sponge-spicules, making up the larger part of the chert.

### Protozoa.

**Kent's 'Manual of the Infusoria.'** †—Four parts of this work (to be completed in six parts of about 800 pp. and 48 plates in all) have been issued.

Chapter I. is "Introductory," and contains a chronological summary of the General History of the Infusoria from the time of their discovery by Leeuwenhoek in 1675 to the year 1880. Chapter II. "The Sub-kingdom Protozoa," contains the taxonomical, biological, and structural values and affinities of the various groups of Infusoria, with suggestions for their classification. The Spongida and Myxomycetes or Mycetozoa are treated as belonging to the Protozoic system. The Protozoa are divided into four principal sections. (1) The PANTOSTOMATA, without any proper oral orifice, food being incepted indifferently throughout the body. These include the Amœbina, Gregarinida, Foraminifera, Radiolaria, and some of the Flagellata. (2) The DISCOSTOMATA, also without distinct oral orifice, the inception of food being limited to a discoidal area occupying the anterior extremity of the body. This division contains the collar-bearing Flagellata (Choano-Flagellata of the author) and the Spongida. (3) The EUSTOMATA, having a true mouth and containing the majority of those organisms that collectively constitute the class Infusoria, in the more modern use of the term, embracing the Ciliata, the Cilio-Flagellata, and such Flagellata as *Euglena* and *Chilomonas;* and (4) The POLYSTOMATA, with tentacle-like organs radiating from the periphery, each of which serves as a tubular sucking-mouth or for grasping food (and therefore described as "many-mouthed"). Here are placed the Suctorial Animalcules or Tentaculifera of Huxley (*Acineta*, &c.) Chapter III. is on the "Nature and Organization of the Infusoria," and deals with their morphology, cuticular elements or ectoplasm, internal elements or endoplasm, excreted elements, encystment, locomotive and prehensile appendages, oral aperture or cytostome, anal

* Ann. and Mag. Nat. Hist., vii. (1881) pp. 141–3 (2 figs.).

† Kent, W. S., 'A Manual of the Infusoria, including a description of all known Flagellate, Ciliate, and Tentaculiferous Protozoa, British and Foreign, and an Account of the Organization and Affinities of the Sponges.' (8vo, London, 1880–1.)

aperture or cytopyge, the nature and functions of their contractile vacuoles or vesicles, nuclei or endoplast, and nucleoli; their colouring matters, accessory structures (such as trichocysts), and the phenomena of reproduction whether by binary division or fission; external and internal gemmation, sporular multiplication or sexual reproduction; also a discussion of the affinities of the Infusoria to the higher zoological groups, their distribution, and mode of collection and preservation, with a very brief section on methods of investigation. Chapter IV. is a summary of what has hitherto been written on "Spontaneous Generation." Chapter V. contains an extensive discussion of the nature and affinities of the sponges and their near relationship to certain of the Infusoria Flagellata—the Choano-Flagellata, the author considering that "scarcely a shadow of doubt even is admissible concerning the intimate and thorough-going relationship that subsists between one and the other." Chapter VI. recapitulates the systems of classification hitherto adopted, from O. F. Müller, in his 'Animalcula Infusoria' (1786) to that of the author. Chapter VII. and succeeding chapters contain the systematic descriptions of the three classes of Flagellata or Mastigophora, Ciliata or Trichophora, and Tentaculifera.

Amongst the new genera and species may be mentioned * *Dallingeria Drysdali* (a Flagellate), which commemorates the remarkable observations of the two microscopists whose names are adopted.

**Variety of Stentor.**† — Professor Leidy describes a variety of *Stentor* existing in attached groups, of a lilac or amethystine colour, which may be named *S. amethystinus.* It is probably a variety of *S. igneus,* which Ehrenberg describes as bright yellow or vermilion, Stein as blood red, or often lilac-coloured, or vermilion to brownish red. Ehrenberg found it attached to *Hottonia.* Stein says he never saw it fixed, but always swimming.

The new variety was abundant, and invariably found in conspicuous groups, visible to the unaided eye, and when detached, though the animals swam about actively, they were not only disposed to become fixed, but they actually gathered together in groups. They all contained an abundance of chlorophyll, apparently derived from food, but the exterior structure was invariably of a distinct amethystine hue, dependent on fine molecules. The colour was more pronounced in the longitudinal bands approaching the peristome. The nucleus was spherical. In the attached state, when the animal was fully extended and presented a trumpet shape, it was 0·6 mm. long by 0·18 mm. wide at the peristome. This was a common size, but some measured were 0·84 mm. long. In the conical form when swimming, individuals ranged from 0·27 to 0·42 mm. long. In the most contracted condition of oval shape, they measured 0·18 mm. long by 0·15 mm. broad. The nucleus 0·03 mm. in diameter.

Ehrenberg and Stein give for *S. igneus* one-sixth of a line length, so that the variety indicated would appear to be much longer.

* Loc. cit., pp. 309–12.

† Proc. Acad. Nat. Sci. Phila., 1880, pp. 156–8.

**Infusoria in "Dew."**—Mr. W. S. Kent gathered,* in Regent's Park and the Zoological Gardens, on a day of intense fog, a quantity of grass saturated with "dew," and submitted it to examination under the Microscope without the addition of any supplementary liquid medium. In every drop of water examined, squeezed from the grass or obtained from its simple application to the slide, animalcules in their most active condition were found to be literally swarming, the material derived from each of the localities yielding, notwithstanding their close proximity, a conspicuous diversity of types. *Heteromita lens* and *H. caudata* were in all cases abundantly present, as also minute actively motile Bacteria. Other types, such as *Vorticella infusionum*, *Dinomonas vorax*, *Hexamita inflata*, *Trepomonas agilis*, and *Phyllomitus undulans*, and a number of unidentified spores and encystments occurred variously distributed among the samples examined, but even these by no means exhausted the living forms. Two species of Rotifera, *Rotifer vulgaris* and *Theorus vernalis*, numerous *Amœbæ*, *Anguillula*, and various diatoms, chiefly motile *Naviculæ*, contributed their quota towards the host of active living organisms that were found peopling more especially the lower and decaying regions of the dew-moistened vegetation, the collection as a whole being indistinguishable from the ordinary microscopic fauna of a roadside pond.

The data elicited through these observations carry with them, Mr. Kent considers, an important significance, as Infusoria and other minute forms of aquatic life were thereby shown to possess an area of active vital distribution previously undreamt of. Water in its stable and concrete form is no longer, as hitherto presumed, a requisite concomitant of such vital energy. Secure in their spore membranes or encystments, these microscopic beings slumber undisturbed throughout the dry summer days, awaiting only the fall of the evening dew or passing shower to re-awake to active life. The conditions of existence of the animalcules thus found are obvious. Encountered most abundantly on the lowermost blades, coloured brown or yellow, which are beginning to decay, their purpose is to break down and convert into new protoplasmic matter this otherwise waste product. To maintain the balance here, however, and to check the too rapid increase of the herbivorous monads, we find other types such as *Dinomonas*, and various Ciliata, answering to the Carnivora, developed side by side with and feeding in turn upon the plant-eating species.

**Synopsis of Fresh-water Rhizopods.**†—This is a condensed account compiled by Professor R. Hitchcock of the genera and species of all known fresh-water Rhizopods, in regard to which the author points out that there is a broad field for original investigation, comparatively little being known about their modes of reproduction. It is founded on Professor J. Leidy's recent treatise, and is intended as a handy book of reference for those who may not possess the larger

* Kent's 'Manual of the Infusoria,' i. (1880) pp. 140–1.

† Hitchcock, R., 'Synopsis of the Fresh-water Rhizopods.' (8vo, New York, 1881.) 56 pp.

work, which being a Government publication is limited in its distribution. The synopsis will serve to lead the observer directly to the proper genus and species with a fair degree of certainty, and the index is arranged as a check-list, so that a record may be kept of the species found.

The book will undoubtedly be very useful to microscopists, and we should be glad to see the same plan adopted with the Infusoria and Diatoms.

**Rhizopods as Food for Young Fishes.***— Mr. S. A. Forbes has found that the young of some of the "Suckers" (Catastomidæ) have the intestines full of the tests of *Difflugia* and *Arcella.* Professor J. Leidy examined two slides of intestinal contents, and recognized four species of the former genus and two of the latter with an unknown Rhizopod shell in form resembling that of *Arcella discoides.* He considers it an interesting discovery that the young "Suckers" should use the Rhizopod shells to obtain as nutriment their little stores of delicate protoplasm.

**Rhizopods in Mosses.**†—Professor J. Leidy records the finding of seventeen species of Rhizopods among the water squeezed from mosses (*Hypnum* and *Sphagnum*) on the top of Roan Mountain, N. Carolina, at an altitude of 6367 feet.

**Fission of Euglypha alveolata.**‡—Dr. August Gruber states that in well-developed examples of this Protozoon we can detect in or on the superficial layer, and at the point where the nucleus is placed, a number of small corpuscles distinguished by their high refractive power. These are the so-called shell-plates, the presence of which has been noted by various observers. When the *Euglypha* is about to divide, protoplasm escapes from the orifice, and, at about the same time, these concavo-convex plates begin to move and pass towards the orifice; at first they lie irregularly in the sarcode. After a short time about eighty shell-plates will have passed from the parent-animal and formed a kind of fir-cone around the extended protoplasm. Soon the new *Euglypha* resembles its parent, and, during the formation of the new shell, fine granular or coiled lines will have appeared in the nucleus. An essential difference is, however, to be found in the absence at first of any nucleus in the daughter-individuals, which in time come to them from the parent. While the new shell is being formed changes are set up in the nucleus by the appearance in it of fine granules or coiled lines; the nucleus soon alters its form, exhibits a longitudinal striation, the first sign of its future division, and becomes so long as to almost equal the whole length of the parent-animal. It then becomes divided in the middle, and one half passes into the newly formed individual. The author then gives an account of the rotation of protoplasm.§

The chief results of the careful comparison between this and other

* Proc. Acad. Nat. Sci. Phila., 1881, pp. 9–10.
† Ibid., 1880, pp. 333–40.
‡ Zeitschr. f. wiss. Zool., xxxv. (1881) pp. 431–40 (1 pl.).
§ See this Journal, *ante*, p. 69.

Protozoa which the writer institutes is the important conclusion that in the nucleus of the Rhizopoda, just as in that of other Protozoa, we have to do with a typical cell-nucleus.

**Observations on the Gregarinidæ.***—Dr. O. Bütschli finds that Schneider is not correct in denying that there is true encystation and copulation in those Gregarines that unite by pairing; in the larva of the cockroach he found a large number of cysts, and all stages between them and the elongated pair of Gregarines; when encystation is about to take place the individuals of a pair shorten and grow wider, so that the oval gradually passes into the spherical form; an investment is formed for the pair before their individuality disappears, proving distinctly that the cysts are formed of two individuals. The transparent investing layer becomes more apparent by the attachment of foreign particles to its surface; the conjugating animals rotate continually, and form more and more a single sphere; the anterior ends (protomeres) of each individual are still distinct. As the gelatinous investment increases the true envelope of the cyst becomes developed below it; the rotation of the cyst's contents begins to slacken, and there is a change apparent in the boundary line between the two individuals: the true envelope becomes much thicker; and the whole cyst takes on the characteristic ovoid form. These changes occur within the space of an hour and a quarter.

Further observations are more difficult on account of the loss of transparency, but the author has been able to observe the somewhat sudden disappearance of the protomerite in the deutomerite, and the fact that complete fusion of the two individuals does not take place until forty-eight hours after the commencement of encystation and after the cyst has with the fæces left the digestive canal of the host; pseudonavicellæ begin to be formed long before the fusion is complete. Partial fusion may, however, have gone very far; we can only judge that it is complete when the line of separation disappears from the surface. The author states that in a very young pseudonavicella he has distinctly seen a nucleus, excentric in position, and with pale, not granular contents; these nuclei appear to arise from the peripheral nuclei which are formed during that process of gemmation which leads to the development of pseudonavicellæ. From his observations on the "sporoduct," the author concludes that the clear non-granulated cords are formed by the separation from one another of granules in the peripheral portion of the contents of the cyst; in this axis of the cord the finely granular plasmatic plexus becomes arranged in tubular fashion, and within this tube the true sporoduct is formed; the number of these varies with various cysts, and appears to be closely connected with the size of the cyst itself.

After a further discussion of this subject and a reference to the development of the young Gregarines, the author passes to the *Monocystis* which is found in the earthworm; and dealing with the question of the mode of attachment of *M. magna*, he states that he found each imbedded by its somewhat narrow end in a very large ciliated cell

* Zeitschr. f. wiss. Zool., xxxv. (1881) pp. 384–410 (2 pls.).

of the infundibular membrane of the testis; in this form, again, he was able to detect a nucleus in the pseudonavicella.

In the intestine of *Lithobius forficatus* the author observed an oviform psorosperm or coccidium, which, so far as he knows, has never yet been seen in an Arthropod. Here, in addition to the granular protoplasm, there was a pretty large nucleus and a large nucleolus. These appear to give rise to sickle-shaped corpuscles. The author concludes by observing that although their life-history is yet so incompletely known, it is of interest to know that in a Myriapod there are to be found coccidia which have so close a resemblance to the psorosperms observed by Eimer in the mouse.

## BOTANY.

### A. GENERAL, including Embryology and Histology of the Phanerogamia.

**Development of the Embryo-sac.***—In pursuance of the observations of Strasburger, Ward, Vesque, and others,† MM. Treub and Mellink have investigated the mode of development of the embryo-sac in some angiosperms.

A cell of the nucellus, of sub-epidermal origin, produces a longitudinal row of from two to five cells. The lowest cell of this row increases in size and becomes the embryo-sac; the others retreat towards the epidermis of the nucellus, and eventually disappear altogether. The author considers as untenable the view of Warming and Vesque, that the embryo-sac results from the fusion of two or more cells. A careful examination of the history of development in the case of *Senecio vulgaris*, on the other hand, completely confirmed the description of Strasburger, and the same results were obtained from *Luffa petola*, *Centradenia grandiflora*, *Anthurium* sp., *Convallaria majalis*, *Polygonatum vulgare*, *Hyacinthus orientalis*, and *Haworthia subfasciata*.

In *Narcissus Tazetta* the mother-cell of the embryo-sac produces normally only two daughter-cells, the upper one of which disappears; beyond which there is nothing special in the development. In some anomalous cases, however, the upper cell, instead of disappearing, attains a large size, and contains several nuclei; but there is no difference in the lower cell developing into the embryo-sac.

In *Agraphis patula* the mother-cell also produces only two daughter-cells; but in this case it is normally the upper one which becomes the embryo-sac. At an early stage the two have the same size, each having two nuclei. The upper cell gradually increases, one of the nuclei placing itself at each end, a large vacuole occupying the centre. The nuclei then divide twice, so that there are four above

* Arch. Néerl. Sci. exact. et nat., xv. (1880) pp. 452–6 (2 pls.).

† See this Journal, ii. (1879) pp. 903, 905, 907; iii. (1880) pp. 107, 472, 473, 819; *ante*, pp. 260, 264, 266.

and four below. Round three of the upper nuclei are formed cells, the synergidæ and the ovum; sometimes antipodals are produced below, but generally the nuclei appear to remain free. During this time the lower daughter-cell retains nearly the same size; later it usually has four nuclei; in a few cases it was seen to be divided by a delicate vertical septum; in adult ovules it is always readily visible; the septum which separates it from the embryo-sac has thickened considerably.

In *Tulipa Gesneriana* a large sub-epidermal cell of the nucellus itself becomes the embryo-sac, without first undergoing any division. At a certain stage a vacuole is formed, and in normal cases only one of the nuclei remains in the upper part of the embryo-sac, the three others occupying the lower part. Subsequently all the nuclei divide, two being then formed above and two groups of three below. The two upper ones then again divide, forming the two synergidæ and the ovum, the fourth remaining inactive. The two groups of three nuclei at the base of the embryo-sac vary in their behaviour. The three upper ones often unite, forming a crescent-shaped band; in other cases the fusion is incomplete; sometimes the nuclei of this group divide again. In the mature embryo-sac all the nuclei of this group are generally fused into one large one, which may subsequently unite with the fourth upper nucleus. The three nuclei of the lower group also sometimes unite; very rarely are antipodals formed round them; more often they remain unchanged, and finally disappear.

In *Lilium bulbiferum*, as in *Tulipa*, one large sub-epidermal cell is directly transformed into the embryo-sac. In other respects the development is more simple. After the formation of four nuclei, two move to the upper, two to the lower end of the embryo-sac. After fresh divisions of the nuclei, there are, in the upper part, besides the ovum, two synergidæ and one free nucleus; in the lower part one large free nucleus and three antipodals. Cell-walls are frequently formed round the synergidæ, and the protoplasm often assumes a ray-like disposition round the nuclei, this being specially marked when the nuclei are in process of division.

**Strasburger's 'Cell-formation and Cell-division.'***—The third edition of this work contains the record of fresh observations on several points, and considerably enlarges our knowledge of the internal life of the cell. In particular the author insists more strongly than before that the division of the nucleus and cell-formation are two distinct processes, which may be completely separated from one another, although in many cases they come into contact. It is not the nucleus which forms the centre of attraction in cell-formation; forces, on the contrary, are at work in the protoplasm which cause division in it as well as in the nucleus. There is no doubt that the nucleus plays a very important part in the life of the cell; Strasburger attributes to it, though without positive proof, the function of a former of albumen.

* Strasburger, E., 'Zellbildung u. Zelltheilung,' 3rd ed. 392 pp. (15 pls.). See Bot. Ztg., xxxix. (1881) p. 52.

**Histology of Stem of Nyctagineæ.***—M. O.-G. Petersen has investigated the minute structure of the stem in this order of flowering plants, especially in the genera *Boerhaavia*, *Bougainvillea*, *Pisonia*, and *Neea*. The foliar fibro-vascular bundles are not formed from any preceding procambial ring, as in *Mesembryanthemum*. In the Nyctagineæ this ring is formed outside the young bundles, and is separated from them by several layers of parenchymatous cells. In its interior are developed secondary vascular bundles, as well as a cambial ring composed of cells juxtaposed in a radial manner. The development of this cambial ring varies greatly. Sometimes it forms a large number of medullary cells between the vascular bundles, causing the medulla apparently to assume a larger size; in other cases it begins at once to form wood-cells. The resulting secondary woody layer varies in appearance in the different genera. The groups of soft bast scattered through the wood consist partly of cambiform tissue, partly also of sieve-tubes, the latter especially in *Mirabilis* and *Oxybaphus*. The primary cortex presents no unusual character. It has no protecting sheath; collenchyma is generally found in it, but the author failed to detect sclerenchymatous cells. Cork is sometimes formed in the layer of hypodermal cells, as in *Pisonia* and *Boerhaavia*, sometimes at a greater depth, at various distances from the epidermis in the same stem, as in *Neea parviflora*.

**Secreting Intercellular Passages and Cystoliths in Acanthaceæ.†**—Russow confirms the statement by Liborius of the presence of a reddish-brown secretion, rhinacanthin, in the ordinary intercellular passages of *Rhinacanthus communis*. In the intercellular passages of the root-stems and leaves of *Justicia picta* he also finds a secretion consisting of small dark red or blackish-brown roundish granules. The secretion of *Myrsine africana* and *Ardisia crenulata* was insoluble in sulphuric acid, but soluble in dilute potash, with a beautiful violet-blue passing over into a dirty violet-brown colour.

Cystoliths were found by Russow to be widely distributed in the internal tissue, especially in the root of Acanthaceæ. They are conical or needle-shaped, and, in *Justicia picta*, *Fittonia gigantea*, and *Sanchezia picta*, often attain the length of 1·6 mm. Their connection with the cell-wall appears to cease at a very early period. According to the species, they were found in the fundamental and epidermal tissue of the root, stem, or leaves; in some species they were altogether wanting. The parenchymatous tissue of the Acanthaceæ is also very rich in needle-shaped crystals of calcium oxalate, not, however, grouped in bundles like raphides, but distributed irregularly and in inverse proportion to the cystoliths.

In the stem of *Hexacentris coccinea* the author found very peculiar needle-shaped cells lying detached side by side within certain cells of the soft bast, bearing an external resemblance to raphides, but with a distinct cell-cavity, and coloured blue by chlor-iodide of zinc. When

* Bot. Tidsskrift, iii. (1879) pp. 149–76 (2 pls.). See Bull. Soc. Bot. France, xxvii. (1880) p. 166.

† SB. Dorpat. Naturf. Ges., 1880, pp. 308–16. See Bot. Centralbl., v. (1881) p. 365.

they are being formed, the cells concerned of the soft bast are divided by periclinal and anticlinal longitudinal walls, so that they are broken up into several elongated prismatic cells, with a nearly square base. But these cells become gradually more and more rounded off, their cell-walls becoming thickened at the ends, like collenchymatous cells. Delicate central lamellæ are then more or less clearly seen, which, however, finally entirely disappear, probably by deliquescence, so that the needle-shaped cells lie loose side by side, retaining, however, somewhat of their original arrangement. These structures have at present been observed not only in the Acanthaceæ, but in many plants belonging to that order. They are especially numerous in the root and leaf-stalks of a species of *Ruellia* and in *Sanchezia picta;* in *Justicia picta* only in the stem; in *Fittonia gigantea* and *Aphelandra aurantiaca* only in the root; in *Hexacentris mysorensis* only in the leaf-stalk. They were not detected in species of *Eranthemum* or in *Aphelandra cristata.*

**Structure of Stomata and Glands.***—In a very elaborate paper on these organs, M. Licopoli gives a very full description of the complicated glands found, for example, on *Rhipsalis*, where the special cells are bordered on the inside, and are surmounted by cells which partially close the opening, and which he calls "labriform excrescences." The special cells he states to be invariably limited to two in number; where more have been described, it is because writers have mistaken for them epidermal cells which take part in the constitution of the stoma. Not only are the special cells liable to become more or less completely cuticularized—sometimes to such an extent as to resist the action of acids—but the cuticle, which descends from the upper surface across the pore, expands in the stomatic chamber below the special cells, forming a vesicular organ of such a character that the exchange of fluids between the interior of the plant and the atmosphere which takes place by the stoma must be effected across a dialyzing apparatus.

Calciferous glands are classified by M. Licopoli into two categories; one connected with the fibrovascular bundles, as those of *Polypodium vulgare*, *Crassula lactea*, and the section *Aizoon* of *Saxifraga;* the other with the parenchyma, as those of the Plumbagineæ.

**Pilosism in Plants.**†—Botanists, M. Ed. Heckel says, have improperly designated by the single name of *pilosism* all the physiological or teratological manifestations of exaggerated development of the pilose system. It is easy to see, however, that these phenomena present a graduated series from the simple physiological fact to the most complex teratological state, which the author calls *deforming pilosism*, because it ends in completely disfiguring the species. Although hitherto all teratologists have considered pilosism to be unimportant, the author thinks it is evident that it represents a higher signification

* Atti R. Accad. Sci. fis. et mat. (Naples), iii. (1879) 72 pp. (7 pls.). See Bull. Soc. Bot. France, xxvii. (1880) p. 151 (Rev. Bibl.).
† Comptes Rendus, xci. (1880) pp. 349–51.

than that of a simple variation, and he proposes to divide these phenomena as follows :—

(1) *Physiological pilosism* includes the formation of hairs or the increase in number of these organs over the whole of the parts of certain plants which are normally provided or totally unprovided with them. This phenomenon is most often produced when plants pass from a moist medium to a dry soil. It is a fact of physiological adaptation, the limit of the action of which is very confined; oscillating between *glabrism* and *pilosism* unaccompanied by alteration of specific characters.

(2) *Teratological pilosism* commences when the specific facies is altered, and attains its maximum when the modifications are so extensive as to originate the notion of a new species. A large number of conditions, capable of producing nutritive disturbances in the plant, may bring about this particular pilosism.

(3) *Pilosism by the punctures of insects, or "balancement organique,"* is clearly distinguished from the preceding in that, being very localized, it cannot alter the physiognomy of the species.

Two cases belonging to the second category are recorded by the author.

For two years *Lilium Martagon* L. has been affected in almost all the plants by a pilosism of variable intensity. In its fully developed state the flower (always the first part attacked) does not present a large superabundance of hairs on the exterior epidermis of its perianth; but, even in the bud and before opening, the whole parenchymatous tissue of the perianth increases to such an extent that all the cells, considerably enlarged and thickened in their enveloping membrane, become visible to the naked eye. Under the influence of this hypertrophy, the flower-bud is rolled in on itself, and the lines of contact of the perianth-leaves disappearing in the bud, the latter bursts at several points, disclosing the completely aborted stamens and ovary. Under these conditions the plant is slightly bent on itself, and long hairs are prevalent on the margins of a large number of the verticillate leaves, which have themselves lost their fulness.

*Genista aspalathoides* Lam. is subject to a yet more marked pilosism. It especially attacks the young branches, deforming them by condensation and torsion; it finally alters the whole foliar and floral system. The flowers thus transformed are (1) normal, but smaller and more hairy than in the pure species; (2) very reduced, and of a cleistogamic appearance, the ovary having only atrophied ovules; (3) completely aborted, and replaced by a ball of hairs, forming a thick felt. This pilosism, when it invades the plant the first year and is reproduced several times, gives to the species a special facies, on which Moris has bestowed the name of var. *confertior*, and De Candolle that of *Genista Lobelii*. It is simply a monstrous variety in consequence of pilosism.

**Fertilization of Alpine Flowers.***—Dr. H. Müller describes his observations on the relations between Alpine flowers and insects.

* Müller, H., 'Alpenblumen, ihre Befruchtung durch Insekten und ihre Anpassungen an dieselben.' (8vo, Leipzig, 1881.) 612 pp. (173 figs.). See Bull. Torrey Bot. Club, viii. (1881) pp. 13–14.

After dealing with the individual peculiarities of 422 specimens of phanerogams (the descriptions being supplemented by many excellent figures), and enumerating the insects found on each, the author considers at length the significance of these peculiarities; discusses the adaptations of flowers to insect visits, and the extent of these visits; the adaptations of insects for floral activity, and the variability of Alpine flowers; and makes an extended comparison of Alpine flowers with those of the lowland.

As was to be expected, the author finds that everywhere, even to the limit of phanerogamic life—the line of perpetual snow—the rule holds that cross-fertilization, constant or occasional, is provided for in every species, so that not a single flowering plant is known which is incapable of being crossed at some time. A series—from the simplest anemophilous flower, whose only attraction to insects lies in its pollen, to the most highly adapted bee or butterfly flower, with fragrance, attractive form and coloration, and nectar—is fully traced and illustrated by many examples. A valuable feature of the work is the large number of comparative tables, which enable the reader to see at a glance relations which, without this aid, would require much study for their detection. These show very clearly that as flowers ascend in the scale of development, their visitors, though often decreasing in actual number of species, become limited more and more to certain groups whose floral activity is great, and from whose visits they receive the greatest profit. In spite of the frequently recorded scarcity of insects at high altitudes, under some conditions, the author says, "I have not been able to convince myself that, in the Alps, flowers as a whole are relatively less visited and crossed by insects than in the lowland." This results partly from the consolidation of vegetation into veritable flower-gardens, a circumstance very favourable to insect visits anywhere; and it is found that while in the pleasantest weather a moderately cool breeze suffices to drive the insects quickly under shelter, a quiet, sunny day, coming suddenly after several cold and rainy ones, brings them out in great abundance, their enforced concealment and fast having whetted their appetites and rendered them exceedingly active in their visits to the flowers. This is strikingly illustrated by the fact that 1877, which was cold, damp, and rainy, but with occasional quiet, warm days, was not less productive of observations than the preceding summer, when for weeks together there was scarcely a cloud overhead. So while one day there may not be an insect visible, the next may witness them in great abundance.

From a table showing the abundance and activity of the different orders of insects, it appears that in ascending the mountains the relative number of Coleoptera and Hymenoptera decreases, while that of Diptera and Lepidoptera increases. Thus, in the lowlands, of every 100 flower-visiting insects, 15·3 are Coleoptera and 30 Diptera, while 43·6 are Hymenoptera, and but 9·3 Lepidoptera; but above the timber line, with 6·8 per cent. of Coleoptera, we have 43·6 per cent. of Diptera, and with 18·3 per cent. of Hymenoptera, 30·7 per cent. of Lepidoptera. This renders intelligible the great abun-

dance of narrow and partly closed flowers, and of those which, like many species of *Saxifraga* and *Veronica*, are especially attractive to Syrphidæ and other Diptera; whereas, without a knowledge of the relative distribution of the flower-frequenting insects, it would be a hopeless riddle.

The author has followed the excellent plan, adopted in his earlier book, of compiling a systematic index to the insects observed, connecting with each species the flower it frequents and the degree of their adaptive development.

**Nectaries of Flowers.**—M. G. Bonnier, in papers published in 1879 and 1880,* claimed to have established that the colour of the corolla, the perfume, &c., are not connected with the formation of nectar, and do not act, therefore, to attract insects and effect cross-fertilization. Dr. H. Müller has published † a strong criticism of M. Bonnier's views, in which he contends that the proofs supposed to be given are nothing but "an uninterrupted chain of grossly illogical affirmations," and asserts that the author has "endeavoured with the weapons of a child to overthrow one of the broadest and best founded of theories."

**Extra-floral Nectaries.**‡—V. A. Poulsen describes the extra-floral nectaries in the following plants:—

1. *Batatas glaberrima.*—In the cortical tissue of the flower-stalk immediately below the sepals; they are hollow cavities clothed with short, crowded, secreting glandular hairs, and opening by a narrow slit. The nectaries on the leaves of *B. edulis*, previously described by the same author, occur also in this species.

2. *Helicteres verbascifolia* and *spicata.*—Nectariferous emergences, which in *H. spicata* have a beautiful red colour at the base of the flower-stalk.

3. *Turnera ulmifolia*—Emergences or growths of the periblem at the base of the lamina of the leaf; morphologically, these are leaf-teeth.

4. *Qualea Gestasiana.*—Saucer-shaped, short, cylindrical glands, at the base of the leaf-stalk.

The author also gives a description of the remarkable floral nectary of *Nelumbo nucifera.*

**Caltha dionæfolia, an Insectivorous Plant.**§—This Antarctic species was first described by Dr. Hooker, and the resemblance of its leaves pointed out to those of *Dionœa muscipula.* W. Behrens now gives a fuller description of the structure, which is even more perfectly contrived for the capture of insects than that of *Dionœa.* Both the margin of the lamina and the appendages to the leaf bear numerous sharp, stiff teeth, pointed at right angles to the surface of the leaf. The inside of the lamina is densely covered with viscid

* See this Journal, ii. (1879) p. 748, and iii. (1880) p. 114.
† Kosmos: Transl. in Rev. Sci. Biol., vii. (1881) pp. 450-65.
‡ Naturh. Foren. videnskab. Meddelelser, 1881 (1 pl.). See Bot. Centralbl., vi. (1881) p. 7.
§ Kosmos, ix. (1881) pp. 11-14 (7 figs.).

papillæ. The lamina and its appendages occupy different positions with respect to one another, so that the leaf may be either open or closed. The entire mechanism acts in the same way as that of *Dionœa.*

**Power of Movement in Plants.***—Mr. Darwin's book under this title is an extension, as it were, of his previous treatise on climbing plants. He shows that every growing part of every plant is continually moving round—"circumnutating" as he calls it. The movements of climbing plants, the upraising and depression of leaves, the movements of certain parts towards or from the light, all are modifications of this circumnutatory tendency. The most novel portions of the treatise are those relating to the movements of seedling plants, the upper part of which is alone sensitive to light and transmits an influence to the lower part, causing it to bend. If, therefore, the upper part be shielded from the influence of light, there will be no movement of the seedling, even though the lower portion be exposed to the light for hours. Still more novel and remarkable are the facts that Mr. Darwin brings forward with reference to the movements of the radicles and minute root-fibres. These, as it appears, are in constant movement, so far as the obstacles in their way will permit, and it is easy to see of what use this rotating movement is in enabling them to penetrate between some obstacles or to avoid others. The tip of the root, moreover, is sensitive to the touch and to various stimuli, and when thus excited it transmits an influence to the upper part, causing it to bend from the pressed side. On the other hand, if the tip be exposed to a current of watery vapour on one side the upper part of the radicle bends to that side.

The bulk of the book consists of the record of a series of elaborate experiments proving the existence and nature of the movements alluded to. The experiments were made by affixing to the part to be examined, by means of shellac, a fine thread of glass tipped by a minute dot of sealing-wax. A card with a similar black dot was affixed close by, and so arranged that on beginning an observation the black dot on the glass filament and that on the card coincided in position. As the plant or part of the plant moved, while the card was fixed, the relative position of the two black dots of course varied, and the degree of variation was marked upon the horizontal or vertical glass plate through which the plant was observed by a series of marks, which, when subsequently connected by lines, represented to some extent the course of the moving object. It is probable that some more accurate and "self-recording" register will hereafter be devised; but for Mr. Darwin's present purpose, for the mere establishment of the facts in their broad outlines, this plan is sufficient.

The tendency of modern investigation has been to break down in many points the alleged distinctive marks between plants and animals. One by one the old supposed distinctions have been abandoned, so that at present the prevalent belief is that all life is essentially one,

* Darwin, C. (assisted by F. Darwin), 'The Power of Movement in Plants,' 573 pp. and 196 figs. (8vo, London, 1880.)

and that its manifestations are exerted through the medium of machinery fundamentally identical in character. In accordance with these views Mr. Darwin points out the resemblance between the movements of plants and many of the actions performed unconsciously by the lower animals, the most striking illustration being in the kind of imperfect reflex action which is shown to occur when a certain portion of a plant is stimulated by a touch or otherwise, the influence being transmitted from the point of contact to some other point, which, as a direct consequence of this transmitted influence, moves just as the telegraph needle moves when a current is generated in the far-off battery. "It is hardly an exaggeration to say," remarks Mr. Darwin, "that the tip of the radicle thus endowed, and having the power of directing the movements of the adjoining parts, acts like the brain of one of the lower animals: the brain being seated within the anterior end of the body, receiving impressions from the sense organs, and directing the several movements."

**Auxotonic Movements of Vegetable Organisms.***—The term *auxotonic* is applied by de Vries to the movements caused by an augmentation of the turgidity of an organ which is not followed by contraction, as in heliotropism, geotropism, nutation, epinasty, and especially in the movements of tendrils; *allassotonic* to those in which the augmentation of turgidity alternates with a diminution of volume, as in the movements of the sensitive plant and of the stamens of the Cynaraceæ. He now investigates the problem of the part played by turgidity and by intussusception in the phenomena of auxotonic curvatures of multicellular organs.

The general result of his experiments is stated by de Vries to be that the cause of auxotonic curvatures is an augmentation of the force of turgidity in the cells on the side which subsequently becomes convex. This augmentation causes the cells on that side to absorb more water, and in consequence to increase in size; thus originating the curvature. The enlargement of the cells causes a distension of the cell-walls, and this promotes intussusception; and the curvature thus becomes permanent.

Irritation determines a production of osmotic substances in the parenchymatous cells; and this production is the more abundant, the nearer the cells are to the point of irritation. The commencement of the epinastic movement is caused by the passage of substances by osmose into the parenchyma. In multicellular organs which are in process of growth, specific gravity and light, as well as other exciting causes, bring about curvatures by accelerating endosmosis on one side of the organ, which determines the increase in length. Among the osmotic substances which give rise to turgidity in the cells of plants, the author considers vegetable acids to play the principal part; the unilateral acceleration of growth, due to external causes, being dependent on the acceleration of the production of these acids.

As stated by Sachs, the geotropic and heliotropic movements of

* Arch. Néerl. Sci. exact. et nat., xv. (1880) pp. 295-312.

unicellular organs like *Vaucheria*, *Mucor*, and the root-hairs of *Marchantia*, are not due to changes in the turgidity, but to variation in the growth of the cell-wall.

**Movements of Tendrils.***—H. de Vries has applied to the determination of the cause of the movements of tendrils the plan of injection of water proposed by Dutrochet, the air of the intercellular spaces being first removed by the air-pump and then replaced by water. The plants experimented on were *Sicyos angulatus*, *Cucurbita Pepo*, and *Echinocystis lobatá*, and the general conclusions arrived at were as follows :—

1. All the movements of tendrils are temporarily increased by the injection of water, the only exception being the retrograde movement which takes place after the removal of the support.

2. Straight tendrils, when not irritated, remain straight after injection with water.

3. The acceleration is much more considerable in the case of irritable than of epinastic movements ; after a short irritation tendrils attain a much greater degree of curvature than would be possible, in the same conditions, without injection.

As regards the cause of the movements, the author considers it to be proved that

4. The force of turgidity in the parenchyma of the tendrils at the time of the epinastic straightening, and subsequently at the time of the epinastic unrolling, is partially inactive.

5. Irritations provoke suddenly a very considerable increase in the force of turgidity, much more considerable than is indicated by the movements which take place under ordinary circumstances.

**Daily Periodicity in the Growth of Plant-stems.**†—In the life-phenomena of plants, there occur, under constant external conditions, certain peculiar regular variations connected more or less closely with certain hours of the day, and which call for investigation, as to whether they are due to a direct or an indirect action of light. With regard to the periodicity of the quantities of sap flowing from cut stems, and the periodical movements of leaves, it was shown by Baranetzky and Pfeffer that they were produced, not by the organization of the plants, but by the periodical action of light, and that in darkness they continued for a time as an after-action. Again, the proved daily periodicity of the tension of tissues has been shown by Kraus to be directly dependent on the action of light. For the growth in length of stems under normal conditions of light, Sachs has likewise discovered a daily periodicity, inasmuch as the growth by night is always considerably greater than by day. On the other hand, observations on plants which are kept continuously in darkness, have not, apparently, been decisive ; for sometimes periodical variations appeared, and sometimes they were wholly wanting. Baranetzky

* Arch. Néerl. Sci. exact. et nat., xv. (1880) pp. 269–94.

† Mém. Acad. Imp. Sci. St. Petersb., xxvii. (1879) 91 pp. 5 figs. and 5 charts. See Naturforscher, 1880, and Engl. Mech., xxxii. (1880) pp. 7 and 108.

has lately investigated the phenomenon afresh, and communicated his results to the St. Petersburg Academy.

Since the observations as to the nature of the growth had to be made chiefly in continuous darkness, only those plants were suitable whose stems are qualified by their rich provision of nutriment (bulbous plants) to grow a long time regularly in the dark. The experiments were, therefore, chiefly made with *Gesneria tubiflora.* The growths were automatically measured and recorded by means of apparatus which the author describes. The temperature prevailing during the observation was either read off from a thermometer in the neighbourhood of the plant, or registered every hour by a thermograph. The space in which the plants were kept was so completely darkened that the eye, even after a long stay, received no impression of light, and care was taken to have as favourable and uniform conditions of growth as possible.

It appeared, then, quite unmistakably, that the growth in length of the stems has a periodicity quite independent of the direct action of external agents; it is differently manifested in different plants, but always well marked. Even in perfect darkness the plants experimented with showed a periodically increased and diminished growth, such that in the course of every six hours a maximum and minimum occurred. This periodicity was commonly, in the first days after the darkening, very regular, and, as the curve of temperature shows, quite independent of temperature as well as of the direct action of light, which, indeed, was excluded in the experiments. After two or three days, however, the regularity of the periodicity was lost, inasmuch as, while the energy of the growth was commonly increased, the amounts of the daily variation were diminished, and secondary variations appeared, which soon so far took the upper hand over the weakened daily periods that these were at length quite masked and unrecognizable. These secondary variations were in their occurrence and duration very regular, and appeared to be due to causes which are in the internal organization of the plant, and therefore always active. Only the active factor which produces the daily period of growth is capable, so long as it is in full activity, of ruling and suppressing these secondary variations.

A comparison of the position of the maxima in the growth-curves of *Gesneria* shows that the period is not a 24-hours one ; the duration of the separate periods in different individuals rather varied between 16 and 20 hours, whereas in one and the same plant-stem it was within narrower limits, and often remained unchanged several days. Obviously, the maxima must thus be displaced relatively to the hours of the day ; generally their appearance was dependent on that of the first maximum, which they followed in the given epochs. Other plants showed other periods, but their course was similar to that in *Gesneria.*

As to the natural origin of this demonstrated independent periodicity of growth, Baranetzky altogether adopts the view given by Pfeffer for the periodic movement of leaves. Pfeffer showed (he says) that if a plant which has ceased from its periodical leaf-motions, in conse-

quence of continuous illumination, be suddenly darkened and then kept in darkness, the leaves first perform the sleep-motion, and after a time expand again. The first motion is the simple stimulus motion, or, as Pfeffer calls it, "reception motion," which in periodically moved leaves, is always produced by sudden changes of illumination. The plant, however, does not remain stationary, but the movements are several times repeated, in about equal daily periods, but with even less energy. In this way Pfeffer obtained, by simple darkening of the previously quite motionless leaves, curves of motion which are very similar to those given by Baranetzky for the growth of *Gesneria*. Pfeffer, therefore, well compares the periodically moved leaves to a pendulum, which, after receiving an impulse, makes a whole series of rhythmic oscillations.

That the periodicity of the growth in length is an altogether similar phenomenon, Baranetzky proved by an experiment, in which he exposed to light for 10 hours a *Gesneria* which had remained in darkness till every variation had disappeared, and then brought it into darkness again; a daily period could then only be indistinctly perceived by the points of the curve. The plant was then exposed 16 hours to the light, and again brought into darkness; and now the periodicity appeared quite regular, with all its characteristic peculiarities. The 10 hours' illumination was thus not sufficient to call forth the extinguished periodicity, but an illumination of 16 hours was fully so; the following darkness called forth a whole series of variations, each of which took about 8 to 10 hours.

Herr Kraus has also recently investigated the daily variations in the dimensions of thickness of tree-stems. His measurements were made chiefly on dicotyledonous trees, but also on *Dracæna Draco* and *Pinus Strobus.** The results are briefly as follows:—(1) The stems of trees are subject to a daily recurrent, regular variation of their diameter. (2) The diameter diminishes steadily from the earliest morning hours to the early afternoon, at that time reaching a minimum. There is then a constant increase of diameter to a first (small) maximum when darkness comes on. After sinking a little, the dimension increases again till dawn, when a (great) maximum is reached. (3) This course of variation thus coincides exactly with the course of variation in tension. (4) The curves show that the progress of variation of diameter, and that of temperature, are, on the whole, inversely correspondent; to rise of temperature corresponds a diminution of the diameter, and conversely. (5) The maxima and minima, however, do not quite coincide; the nightly maximum thickness occurs long before the minimum of temperature of the night, and the day-maximum of temperature before the minimum of the thickness. Then, besides temperature, other factors must operate.

In stems of 40–50 mm. the differences in size were mostly under 0·5 mm.

**Freezing of Plants.**†—H. Müller-Thurgau has applied low temperatures to plants, with the view of ascertaining the effect of

* Bot. Ztg., xxxviii. (1880).

† Naturforscher, xiii. (1880) pp. 121–3.

freezing upon their tissues. Sections made of pieces at $-5°$ to $-10°$ C. exhibit ice in the tissues; it forms two layers of icy rods, and is found between, not within, the cells, which are somewhat compressed and separated by the intervening crystals, but resume their original position more or less when the ice melts.

Experiments show that it is only pure water, not an organic fluid, which thus freezes in the tissue. A lower temperature than the freezing-point of the substances contained in the tissues is required, in order to produce the ice; this is in accord with the well-known phenomena exhibited by solutions of certain salts which submit to temperatures below their freezing-point without solidification, if not disturbed.

Capillarity also appears to exercise an influence on the freezing-point; fluid which is unfrozen at $-7°$ or $-10°$ becomes solidified when brought into contact with a crystal of ice, and the temperature then rises almost to 0° C.; this is what appears to take place in the minute intercellular passages.

The solution of various substances in the intercellular fluid has also some hand in the lowering of the freezing-point, but is not the only cause. Proceeding on the hypothesis that the cell-wall consists of minute particles ("micelli") closely apposed, but with spaces between them, Müller-Thurgau explains the fact that the cell-wall does not freeze even when the ice forms on its exterior, by the fact that capillarity has greater power in these excessively narrow spaces between the micelli than in the intercellular spaces, and considers that, further, a thin lamina of unfrozen water separates the cell-wall from the ice.

The contained gases of the fluids are given out in the process of freezing and are visible as bubbles in the ice; the dissolved substances accumulate between the ice and the cell-wall.

The effect of bringing a potato at a temperature of 15° C. into an atmosphere which is at from $-4°$ to $-4 \cdot 5°$ C. is first to gradually lower the temperature to about $-3°$ C.; it then rises rapidly to $-0 \cdot 8°$ C., and after an hour begins to fall again; when the potato is brought back into the warm chamber the temperature rises with great and increasing slowness: the sudden rise of temperature in the cold chamber is due to the commencement of ice formation as above explained. The actual freezing-point of the tissues is $-5°$. The freezing-point of plants which contain little water (e. g. the leaves of conifers), is lower than that of those which contain much (e. g. *Sempervivum* leaves).

**Development of Heat during the Germination of Plants.***—The attempt has been repeatedly made to demonstrate the development of heat in plants in such a way as to apply the thermometer to it; but although the existence of this phenomenon has been determined, i. e. by comparative experiments, it has been hitherto out of the question to measure its amount; the results afforded by the thermometer depend so entirely upon a number of external conditions,

* Bull. Soc. Bot. France, xxvii. (1880) p. 141.

that it seldom remains quite constant even when the state of the plants submitted to it remains unchanged. Practical scientific results can only be obtained by the use of the calorimeter, which has been applied by G. Bonnier in the following manner:—

Seeds which are either germinating or about to germinate are placed in the water of Berthelot's calorimeter, and the temperature of the water observed every minute; if it is necessary that the germination should be undergone in the air, the proper amount of seed is enclosed in a blackened platinum vessel which is placed in the calorimeter. The number of heat-units developed or absorbed is determined by the temperature of the thermometer taken in connection with the specific heat and the weight of the materials used. Among other precautions in reading the results, allowance must be made on the one hand for the action of exosmose in extracting substances from the seeds and the consequent loss of heat by their absorption in the water, and on the other for the production of heat by the development of organic ferments which have nothing to do with the germination. By this method Bonnier has determined the amounts of heat evolved in various stages of the germination of castor-oil, pea, bean, rye, and lupin seeds, identical weights of each being used for identical periods during the different stages. Thus the quantity of heat developed between the commencement of the process and the formation of chlorophyll is determined, and amounts to 1° and upwards per minute. The number of *calories* (units which are equivalent to the raising of 1 kilogramme of water through 1° C.) varies up to 120 in this experiment, shows an increase in all the species of seeds, and passes through a maximum period. The total amount of heat developed during the germination of the pea has been determined; it does not represent, as one would have expected, the amount necessary to produce the carbonic acid which is formed at this time.

**Inulin.***—Having closely investigated the chemical composition and physical properties of inulin, H. Kiliani gives the following epitome of results.

The horn-like inulin is distinguished from the so-called crystalline modification by containing more water. The specific gravity, when deprived of water, is 1·3491. The specific power of rotation of dahlia-inulin, free of water, and dissolved in hot water, is −36° 54′ at 20°–23° C.; when dissolved in cold potassa it is −34°·6 at 20° C. Air-dried inulin has no definite composition. That from the dahlia or from *Inula* dried at 100° has the composition $C_{36}H_{62}O_{31}$; no more water is lost by heating to 130°. Inulin always contains traces of incombustible substances, viz. calcium phosphate and some nitrogenous substance. It melts between 160° and 170° C. Invertin does not convert it into levulose. It does not reduce Fehling's solution. From an ammoniacal silver-solution or gold chloride it separates the metal on heating. Platinum chloride and mercury chloride are not changed.

* Kiliani, H., 'Ueber Inulin: Inaug.-Diss., gekrönte Preisschr.' München, 1880. See Bot. Centralbl., ii. (1880) p. 656.

When heated for forty hours with five parts of water in a closed vessel, inulin is almost completely converted into levulose. Levulin is formed at most only in traces. The change into levulose is effected much more quickly by the action of dilute acids, which brings about saccharification even at the ordinary temperature. By dilute nitric acid, in addition to levulose, formic acid, racemic acid, glycolic acid, oxalic acid, and probably glycoxylic acid, are produced. Dextrose produces, under similar conditions, besides traces of formic acid, only oxalic acid and saccharic acid, but no glycolic or gluconic acid. Inulin is oxidized by chamæleon even at the ordinary temperature into formic and oxalic acids. At the same time there is formed, in very small quantity, a solid substance volatile with aqueous vapour, with the melting-point 46°. The action of baryta hydrate on inulin causes the production of butyric acid in large quantities. By bromine at the ordinary temperature it is very slowly oxidized, with formation of carbonic acid, bromoform, and oxalic acid, acting in the same way as levulose. If a solution of inulin, levulose, or dextrose is heated with silver oxide, glycolic acid is produced, carbonic and oxalic acids being formed at the same time. Dextrose is very rapidly oxidized by bromine at the ordinary temperature into gluconic acid, according to the equation $C_6H_{12}O_6 + Br2 + H_2O = C_6H_{12}O_7 + 2BrH$. The action of concentrated hydriodic acid on inulin and levulose results in the formation of a non-volatile viscous substance, and a small quantity of an oil containing iodine. Nascent hydrogen produces from inulin neither mannite nor mannitan. Heating a solution with oxide of lead does not cause the production of lactic acid; on heating with chlor-benzoyl, its benzoyl derivatives are not formed.

The author does not agree with the view of Prantl that inulin is closely related to cane-sugar; nor with that of Rose that it stands between starch and sugar. The parallel drawn by Prantl between the two substances depends on purely physical and not on chemical properties. He is of opinion that it is more closely allied to levulose than to any other carbo-hydrate, passing into it with great facility, and appearing to be simply its anhydride. It is distinguished from levulose by not reducing Fehling's solution, by not being directly fermentable by yeast, and especially by the fact that from inulin nascent hydrogen does not give rise either to mannite or to mannitan. Next to levulose it seems most closely related to starch; starch having the same relation to dextrose that inulin has to levulose.

**New Botanical Journal.**—The first three numbers are issued of a new monthly botanical journal, the 'Archives Botaniques du Nord de la France; Revue botanique mensuelle, publiée sous la direction de C. Eg. Bertrand.' These three numbers are written entirely by the editor, and consist, after an introductory preface, of the commencement of a treatise on morphology, entitled "Définition des Membres des Plantes vasculaires," and the commencement of a treatise on botany for the use of students, in the form of lessons, the first lesson being devoted to the structure of the seed.

## B. CRYPTOGAMIA.

### Cryptogamia Vascularia.

Apical Cell in the Adventitious Buds of Ferns.*—Recent investigations by Zimmermann do not confirm the results previously obtained on this point by Heinricher.† According to the last named, the adventitious buds of *Asplenium bulbiferum* possess at first a distinctly recognizable apical cell, which disappears after the separation of a few segments, again performing its normal function after the formation of the first frond. Such a temporary disappearance of the apical cell would be an almost unique phenomenon in vegetable development. As the results of a large number of observations, Zimmermann was unable at any time to discover an apex without an apical cell, to be clearly made out with the requisite precautions. It was not in most cases to be directly recognized by its preponderating size; but unmistakably betrayed its nature by the regular course of the cell-walls in the apical region. Nor was he able to confirm Heinricher's description and drawing of a depression of the apical cell.

A distinct apical cell was also made out in the adventitious buds of *Asplenium Belangeri*, *flabellatum*, and *Dregeanum*. The adventitious buds of *Ceratopteris*, which are also very favourable for observation, are distinguished from those of *Asplenium bulbiferum* by having a more pointed apex. The apical cell is also considerably larger; but, as in *Asplenium*, separates segments on three sides.

The author was unable to decide the point whether these adventitious buds spring from a single epidermal cell or from several.

### Muscineæ.

Influence of Light on the Thallus of Marchantieæ.‡—The gemmæ or bulbils of *Marchantia* and *Lunularia* are perfectly symmetrical, and it depends altogether on external conditions from which side the root-hairs spring. The thallus, on the contrary, is dorsiventral, the upper and under sides differing from one another anatomically, the former producing stomata, the latter root-hairs and leaf-like structures. As in the case of the gemmæ, however, it is determined by external circumstances which surface becomes the upper and which the under side. According to the view of Pfeffer the development of root-hairs on one side of the gemmæ is determined by gravitation, and is altogether independent of the influence of light, a view contested by Zimmermann, who maintains that, in addition to gravitation, light exercises a considerable influence on the development of root-hairs.

The experiment on which Zimmermann relies to establish this position is to place the gemmæ in transparent receptacles on water, lighting some of them from above and some from below, the latter by means of a mirror, with the necessary precautions. If Pfeffer's statement were correct, it is obvious that in all cases root-hairs would be produced only on the under side. Zimmermann found, on the con-

* Bot. Centralbl., vi. (1881) pp. 175–6.
† See this Journal, ii. (1879) p. 597.
‡ Verhandl. Phys.-Med. Ges. Würzburg, xv. (1881) pp. 247–52.

trary, that when light reached the thallus from below only, a larger number of hairs were produced on the upper than on the under side. The results were precisely similar for both *Marchantia* and *Lunularia*.

With regard to the dorsiventral thallus which proceeds from a gemma, Zimmermann confirms Pfeffer's statement that the organic upper surface which produces stomata is always the one directly exposed to light.

The results obtained from the thallus of the Marchantieæ correspond in all respects to those recorded by Leitgeb * in the case of the prothallia of ferns; only in the latter there is not nearly so completely differentiated a tissue-system. There appears to be also a difference between them in this respect, that when the dorsiventrality of the thallus of the Hepaticæ is once established, it cannot be reversed; while the contrary is the case with the prothallia of ferns, which may even produce archegonia on both sides.

### Fungi.

**Hymenomycete with the Hymenium on the Upper Side.**—The note on this subject at p. 488 was wrongly headed as "on the *under* side," instead of "*upper*."

**Superior Hymenium in the Hymenomycetes.**†—In accordance with the observations of de Seynes, of a superior hymenium in species of *Agaricus*, P. Magnus has observed a similar phenomenon in *Hydnum repandum* near Fontainebleau.

The upper surface of the pileus bears a number of vermiform excrescences, on the free surface of which is seated the spiny hymenium, which grows partly vertically upwards, partly downwards from the elevated margin of the excrescences. The ordinary positive geotropism may thus become transformed into the negative, as is ordinarily the case with the Clavarieæ, whose hymenium grows vertically upwards. In both cases the effect is the same. In all the Hymenomycetes with isolated hymenium, as the Clavarieæ, Hydnaceæ, Polyporeæ, and Agaricineæ, the growth of the hymenium proceeds vertically either upwards or downwards, the sporiferous basidia being in consequence in both cases horizontal.

**Structure of the Annulus in Hymenomycetes.**‡ — In some species of *Agaricus* the annulus proceeds from the base of the stipes, as in *A. melleus*, and there is no free volva. In these cases, according to M. Cornu, the volva itself constitutes the large and well-developed annulus. An annulus thus formed at the expense of the volva occurs in a considerable number of species of *Coprinus* which, in that and other respects, approach *Lepiota*, although differing in the colouring of the spores; an example is furnished by *C. sterquilinus*. The annulus is in these cases prolonged with the peripheral tissue which encloses the base of the frequently bulbous foot. An annulus of similar origin

* See this Journal, ii. (1879) p. 917.

† Verhandl. Bot. Ver. Prov. Brandenburg, xxii. (1880) pp. 107–8. See Bot. Centralbl., vi. (1881) p. 37.

‡ Bull. Soc. Bot. France, xxviii. (1881) pp. 28–34.

and formation is found in widely separated groups belonging to *Agaricus*, as in *A.* (*Lepiota*) *amiantinus*, *clypeolarius*, *Meleagris*, and *gliodermus*.

There are several instances of pairs of species of *Agaricus* exactly resembling one another in every respect except the presence or absence of the annulus. Thus the very rare *Amanita prætoria*, without a trace of annulus, is otherwise identical with *A. cæsarea*. The same is the case with the ringless *Clitocybe ectypus* and *Armillaria melleus*, with its very broad annulus; and again with *Tricholoma terreus* and *Armillaria cingulatus*.

The section *Mycena* is entirely destitute of an annulus; the pileus is formed long before the elongation of the stipes, which is often floccose at the base, this floccosity representing the volva in a large number of species, but it usually expands only at a later period.

The species of *Boletus* furnished with an annulus are not numerous. In some, as *B. flavus* and *laricinus*, it is large and flowing; in others, as in *B. versipellis* and *aurantiscus*, only the remains are seen at the edge of the pileus; but the presence or absence of the annulus is not used in this genus in dividing it into groups.

The presence or absence, and the nature of the annulus cannot therefore be used as absolute taxonomic characters in classifying the species of Hymenomycetes. In *Collybia* the pileus is formed at a late period at the summit of the already developed stipes, by a kind of duplication of the lamellæ; while in *Mycena* the pileus is formed very early, the stipes afterwards elongating suddenly.

It seems certain that in *Polyporus*, so nearly related to *Boletus*, a large number of species are destitute of a volva, and that this is the case with many genera.

**Supposed Hymenial Glands of Pleurotus glandulosus.***—M. E. Heckel has examined afresh the so-called glandular structure on the hymenial lamellæ of this fungus. A true glandular structure he regards as impossible in a purely cellular organism; and he considers this to be simply a remarkable pilose development which affects principally the organs of reproduction, caused, as in flowering plants, by moisture and want of light. According to M. Patouillard, *Pleurotus glandulosus* differs from *P. ostreatus* in no other respect than the presence on the lamellæ of these white masses of glandular appearance, and M. Heckel proposes therefore to suppress the species, uniting it with the latter as a var. *pilosus*. The view of some writers that the teratological structure is caused by the puncture of an insect, M. Heckel is unable to confirm, finding neither larva nor perfect insect that could be suspected of being connected with the injury. Pilose structures, of a glandular appearance similar to this, occur on other Basidiomycetes.

**New Genus of Sphæriacei.†**—Under the name *Neoskofitzia*, S. Schulzer separates a new genus closely allied to *Hypocrea*, and agreeing

* Bull. Soc. Bot. France, xxvii. (1880) pp. 302–9.
† 'Science,' i. (1880) p. 160.

with that genus in the separability of the spores. The following is the diagnosis:—

*Neoskofitzia* n. g. Stroma nullum. Perithecia gregaria, superficialia, globosa, astoma, interdum tenuissime perforata, membranacea, rigida, nec collabescentia, dilute colorata nec atra. Asci cylindracei aut lineares, brevissime stipitati, 8-spori. Sporæ e cellulis duabus mox vel tandem decadentibus compositæ, recte aut oblique monostichæ, hyalinæ demum fuscescentes. Paraphyses liberæ aut subcoalitæ, filiformes, crassiusculæ.

Two species are described, *Neoskofitzia verruculosa* and *N. pallida*.

**Fungus-parasite of the Sycamore.***—Von Thümen has carefully examined the fungus first described by Hartig,† which attacks and kills seedlings of the sycamore.

When attacked they show a number of small black specks on the cotyledons and first foliage leaves, which afterwards appear covered by a grey felted coating. This consists of the numerous conidiophores of *Cercospora acerina*. The conidia are formed in numbers up to six on the conidiophore, are of a long clavate form, with an acuminate apex, colourless, and furnished with numerous septa. After the formation of spores has gone on for a time, the mycelium passes over into a resting condition in the interior of the host. Its branches swell up, divide continually, and thus is formed either a moniliform filament or a more complicated brown tissue which may be regarded as a simple form of sclerotium. In this condition the fungus may remain for a year; after which the mycelia again germinate and produce new conidiophores. The fungus may be cultivated in artificial nutrient fluids, as the juices of fruits.

**Myxomycetes or Mycetozoa.**—In an appendix to the first volume of the 'Manual of Infusoria,' pp. 470–2, Mr. W. S. Kent replies to Dr. M. C. Cooke's criticism ‡ of his view that these forms exhibit so close an affinity with the typical Flagellate Infusoria that they cannot be retained among the Fungi but must be advanced to a position among the Protozoa, not far from the Spongida.§

As the result of a personal investigation of the developmental phenomena of several Myxomycetan types, including more especially the cultivation of the spores of *Physarum tussilaginis*, Mr. Kent is "prepared even more confidently than hitherto to support the animal interpretation of their nature and affinities." Among the Protozoa their correlation may, he thinks, be accomplished with the greatest ease, their entire life-cycle being precisely parallel in kind to what obtains among the ordinary Flagellate Infusoria, though differing in degree. A primary flagelliferous phase, an intermediate repent, amœboid condition, and a final encysted sporiferous state, these three represent the normal life-cycle of either a Myxomycetan or a simple Monadiform Animalcule. The only distinction manifested on the

* Centralbl. f. d. des Forstwesen, 1880, No. x. See Hedwigia, xx. (1881) p. 63.

† See this Journal, *ante*, p. 84. ‡ Ibid., p. 288.

§ A more elaborate reply was published by Mr. Kent in Pop. Sci. Review, v. (1881) pp. 97–116 (2 pls.).

part of the Myxomycetes, and that, as just stated, being one only of degree and not of kind, consists in the fact that the final act, that of encystment and the resolution of the body into spores, is in this group accomplished by a mass of coalescing or conjugating units, which consequently produce a relatively colossal spore-receptacle or sporangium—the so-called fungus—while in the case of the typical Flagellata it is an isolated monad or two, or a few conjugated units only, that build up the relatively minute but otherwise morphologically and physiologically identical reproductive structure.

"In every structural detail, and in every successive stage of their life-history, the Myxomycetes or Mycetozoa, from their first exit from the spore until their final resolution into similar reproductive elements, may be consistently correlated with the typical Protozoa, and with them alone. While in their compound aggregation, their production of a horny rete or capillitium, and frequent excretion of spicular elements, a departure is made in the direction of the Sponges, the simple flagellate condition of the spore-derived units, and the capacity possessed by them to ingest food-substances at all parts of their periphery, demonstrate their nearest affinity with the simple Flagellata Pantostomata, and of which they may be accepted as representing the most complex factors."

The views of the author are, he considers, strongly supported by Mr. D. D. Cunningham's description * of *Protomyxomyces coprinarius.* This is an organism (developed in the intestinal canal of man, cows, and other animals) which, while presenting an infinity of polymorphic expressions, is reducible to the three component terms common to the two groups of the Myxomycetes and ordinary monads, and which indeed, as recognized by Mr. Cunningham, occupies a position precisely midway between these two series. "With the typical Myxomycetes, *Protomyxomyces* agrees in so far as that the usually relatively large sporangium represents the final disintegration into spores of a multitude of closely associated amœboid elements, surrounded by a common membranous envelope studded with organic granules, these amœboid elements having again commenced existence as simple flagellate monads, Dr. Cunningham's so-called 'zoospores.' From the typical Myxomycetes, on the other hand, *Protomyxomyces* differs in that the amœboid beings thus building up the compound sporangium do not coalesce intimately with one another so as to form a common plasmodium, but while closely approximated, remain individually distinct, each amœboid unit separating into an independent spore-mass, after the manner of the typical Flagellata."

**Myxomycetes with Aggregated Plasmodium.**†—As soon as the processes of growth and bipartition of the myxamœbæ of the Myxomycetes are completed, from the exhaustion of the nutritive material, the course of development continues in two somewhat different ways. In the ordinary case, the myxamœbæ fuse into an articulated plasmodium, endowed with both external and internal movements, and sub-

* Quart. Journ. Micr. Sci., xxi. (1881) p. 287.
† Bull. Soc. Bot. France, xxvii. (1880) pp. 317–22.

sequently becoming fixed and producing a fructification of various forms. Less often (hitherto known only in the case of *Guttulina rosea*, as described by Cienkowski) the myxamœbæ simply aggregate without fusing; no plasmodium is formed in the strict sense of the term, but only a mass of naked cells capable of gliding one over another, out of which the fructification is formed, each cell giving birth, within this fructification, to a spore or a "foot-cell." To the first of these kinds of plasmodium M. Van Tieghem gives the name *fused* (fusionné), to the second *aggregated* (agrégé), and details a considerable number of fresh observations respecting the latter, including the description of a new genus and of four new species.

*Acrasis* n. gen. (*A. granulata* n. sp.). On beer-yeast exposed in a pasty layer black spots appeared which proved to be constituted as follows. An erect filament consisting of a single row of cells, terminates in a bunch of spherical brownish-violet spores, the cell-wall being covered with small elevations. The spores have a diameter of about 0·01 to 0·015 mm., and are often unequal in the same bunch. The inferior cell of the filament is dilated at its base into a palmate spur. Cultivated in fresh urine, the cell-wall ruptures, and there escapes a protoplasmic body without nucleus. Spherical, and at first motionless, this body soon becomes endowed with an amœboid motion, increasing at the same time, and subsequently dividing in two. This bipartition is sometimes effected by a constriction while in motion; more often the myxamœba first reassumes its spherical form and its immotility, and then divides, the two halves becoming rounded off as they separate, and recommencing their changes of form and their power of movement. This process of bipartition proceeds until a large number of myxamœbæ are thus formed.

A new phase then commences. Here and there, usually at points situated at the periphery of the nutrient fluid, a larger or small number of the myxamœbæ approach one another, round themselves off, and form a small cellular mass. In each of these groups, the size of which is very irregular, the elements, although closely aggregated, remain completely independent and capable of moving over one another, in consequence of which the mass raises itself perpendicularly, and forms in the air a cone which becomes gradually longer and thinner. The cells of the axile row, one and a half times or twice as long as broad, first develope a cell-wall of cellulose, and form the "foot." Along this solid axis the external cells glide and raise themselves, assuming a spherical form, and becoming invested with cellulose, thus forming a longer or shorter bunch of spores. The cell-wall of the spores then becomes cuticularized and covered with small elevations, and assumes a dark violet colour; the fructification thus attaining its definite characters. The number of spores in the fructification and the length of the foot vary greatly, according to external circumstances; and occasionally the fructification is of a somewhat more complicated character. If, during the period of growth and bipartition, the conditions become unfavourable, the myxamœbæ become rounded off and encysted, increasing then by a kind of budding.

M. Van Tieghem further describes two new species of *Guttulina*, *G. aurea* and *sessilis*, and two of *Dictyostelium*, *D. roseum* and *lacteum*.

These three genera M. Van Tieghem proposes to erect into a distinct group of Myxomycetes, under the name *Acrasiaceæ*, the whole family being then classified into the following primary divisions:—

| | | |
|---|---|---|
| Plasmodium fused .. | endosporous | *Myxomycetes* proper. |
| | exosporous | *Ceratiaceæ*. |
| Plasmodium aggregated .. .. .. | | *Acrasiaceæ*. |

The position of the genus *Plasmodiophora* remains uncertain. It may constitute a third family of the first division, or it may be a type of a third primary division with undivided plasmodium, without either fusion or aggregation, in which case it would form a link between the Myxomycetes and the Chytridinieæ.

The author suggests that the increasing heterogeneity of the Myxomycetes will result in the abolition of the group and the placing of their principal divisions in the various orders of fungi to which their fructification presents the closest resemblance.

**Ferments.***—Mr. D'Arcy Power gives a *résumé* of the present state of our knowledge on this subject, pointing out that as non-morphological ferments have been shown to exist in very low forms of life, vegetable as well as animal, there does not appear to be any valid reason why the Saccharo- and Schizo-mycetes should not be dependent on a ferment which is secreted by them, and is in reality of the non-morphological type; for it can scarcely be supposed that the secretion of these substances should cease suddenly and abruptly on reaching the Protophytes and Protozoa. The experiments of Claude Bernard and Kühne show, in fact, that such is not the case, and that an extract containing a non-morphological ferment can, in some cases at any rate, be obtained from a ferment of the morphological group.

**Fermentation by Schizomycetes.**† — In the sixth instalment of his paper on this subject, A. Fitz describes experiments with the following nutrient fluids:—calcium lactate, calcium glycerate, and glycerin; the ferment being Pasteur's butyric ferment alone or mixed with other Schizomycetes which also produce butyric acid. The following are the results of four special experiments:—

1. 100 g. of calcium lactate. Principal product of fermentation:—propionic acid, with small quantities of succinic acid and traces of alcohol. 2. 100 g. calcium lactate, but a different ferment. Products of fermentation:—propionic and normal valerianic acid, with traces of alcohol. 3. One-half k. calcium lactate, with Pasteur's butyric ferment. Products:—Butyric acid, ethyl- and butyl-alcohol in nearly equal quantities. 4. Three k. calcium lactate, with the same ferment

* St. Bartholomew's Hospital Reports, xvi. (1880).

† Ber. deutsch. chem. Ges., xiii. (1880) pp. 1309–12. See Bot. Centralbl., vi. (1881) p. 2.

as in (2). Products:—An alcohol (probably ethyl-alcohol), propionic and normal valerianic acid.

The fermentation of glycerin (6120 g.) produced 675 g. of anhydrous alcohol, of which 440 g. consisted of normal butyl-alcohol, the remainder of ethyl-, with small quantities of normal propyl-alcohol. The remaining products of fermentation were not examined, the object being to determine the variations in the quantity of butyl-alcohol produced in butyric fermentation. From a microscopic examination of the schizomycete during fermentation the author could determine the relative quantity of butyl-alcohol that would be produced. The fermentation of calcium glycerate yielded methyl-alcohol, formic, and a small quantity of acetic acid.

**Metamorphoses of the Schizomycetes.*** — Dr. Zopf's investigations into this subject have led him to support the view of Nägeli and others that the various forms of Bacteria, viz. *Micrococcus*, *Bacterium*, *Bacillus*, *Leptothrix*, *Spirillum*, and *Spirochæte* are merely developmental stages of a single species. Thus he finds all the above forms to be produced in the course of the development of *Cladothrix*, one after the other, and partly one from the other.

In the development of *Crenothrix polyspora* several of these form-genera have made their appearance. The peculiar *Beggiatoa alba*, whose cells contain strongly refractive particles of crystalline sulphur, also shows similar phenomena. Dr. Zopf unites the three genera *Crenothrix*, *Beggiatoa*, and *Cladothrix* into one family, the *Crenotrichaceæ*, owing to their essential agreement in the phenomena of their development.

**New Bacteria.**†—E. Duclaux has already described the organisms which arise in imperfect preparations of "cantal" cheese, viz.: 1. An alcoholic ferment; 2. The lactic ferment; 3. The butyric ferment; 4. The uric ferment; 5. A new anaerobic vibrio (vibrion chaînette); and 6. A new aerobic vibrio (filament coudé). To these he now adds seven new species, of which four are aerobic and three anaerobic. These are fully described and figured.

1. "Filament dodu." Cultivated in milk in a very open dish, this ferment forms short thick cells with a diameter of 1 $\mu$, and a length of 2–3 $\mu$. After some time the milk becomes transparent and yellowish, the cells elongate and divide by transverse septa, forming a continuous pellicle on the surface. In each cell there appears a shining nucleus or "spore," the cell-wall becoming absorbed. The "filament dodu" transforms the oxygen of the air into a nearly equal volume of carbonic acid. A portion of the casein is changed into a substance resembling syntonin, which, in the somewhat alkaline milk, precipitates in the pellicle. Besides ammonium carbonate, and butyrate, leucin and tyrosin are also found in the milk, indicating a considerable process of combustion.

2. "Filament ténu." Small very motile cylindrical rods of about

* Cf. Kosmos, vii. (1881) pp. 469–70.

† Ann. Agronomiques, vi. (1880) pp. 161–79. See Bot. Centralbl., vi. (1881) p. 74.

$1 \cdot 5\,\mu$ diameter and various lengths. They are aerobic and shift their position rapidly to the margin of the cover. They elongate and form a firm velvety pellicle; these filaments divide into short cells, each of which forms a spore, while the cell-wall becomes absorbed. In the presence of carbonic acid the milk coagulates; the coagulum finally disappears entirely without formation of gas.

3. "Filament granuleux." Short thick cells with a diameter of $\frac{1}{800}$–$\frac{1}{900}$ mm. Each cell contains a quantity of small parietal granules like *Bacillus ulna*. In its vermiform movements it resembles *Vibrio rugula;* they become gradually slower, and finally entirely cease. The filaments form a thick easily broken pellicle on the surface. Each cell forms one or more spores. The "filament granuleux" succeeds better in extract of meat than in milk, forming in it a larger number of spores, the cells also being more vigorous. It is distinctly aerobic, does not live in carbonic acid, and only penetrates slowly beneath the surface of the nutrient fluid. The proteinaceous substances attacked by other ferments, such as syntonin, Liebig's extract of meat, &c., are vigorously attacked by this.

4. "Filament effilé." This ferment developes neither in milk, artificial solution of casein, albumin, nor syntonin; but very readily in solution of extract of meat. It can therefore only affect substances already prepared, and may play a part in the ripening of the cheese. In extract of meat it forms very delicate cylindrical rods, which are either isolated or associated. At first they are not flexible or motile, but soon become irregular, protuberances appearing on them here and there, while the intermediate parts become continually thinner, so that the filament ultimately has a remarkable appearance, resembling an antherozoid. The spores are formed in the swollen parts. The "filament effilé" is aerobic; ammonium carbonate and butyrate are found in the fluid.

Various other aerobic bacteria occur in cantal-cheese, often causing the production of a bitter substance, or giving rise to various colourings. The Mucedineæ also bring about phenomena of combustion in the substratum, with development of leucin, tyrosin, and oxalic acid.

5. "Vibrion massue." Consists of very motile cylindrical rods, $1\,\mu$ in diameter. They elongate, and form gelatinous transparent flakes on the surface of the fluid. Each filament breaks up into small cells which are solitary or united in pairs; each swells up into a club-shape at the end, and there produces a spore. This microbium is both aerobic and anaerobic; it causes the production of a gas which consists of two parts of carbonic acid and one part of hydrogen; a portion of the latter is transformed into sulphuretted hydrogen.

6. "Vibrion filiforme." Both aerobic and anaerobic; very nearly related to the last. The gas which is evolved by it consists of eight parts of carbonic acid and one part of hydrogen; a small portion of the latter passing into sulphuretted or phosphuretted hydrogen.

7. "Vibrion claviforme." Anaerobic; forming small cylindrical or hour-glass shaped rods; more than two are never found united into a filament. At one end of the filament is formed a gelatinous swelling,

which contracts into a round black spore. The gases evolved are somewhat variable, usually consisting of about two parts of carbonic acid and one part of hydrogen.

**Bacteria in the Choroid.***—Duke Charles of Bavaria claims to have discovered bacteria in the choroid coat of two eyeballs. The vessels of the vascular network were, it is said, found to be closely packed with bacteria, which were most abundant in the larger capillaries just before their ultimate divisions, and least numerous in the small arteries and veins.

**Rôle and Origin of some Microzymes.**†—M. A. Béchamp finds that where animal or vegetable detritus accumulates under water in marshy places, bacteria, &c., become developed, from which carbonic acid and methyl hydride are evolved, as well as alcohol and acetic acid. Waste lands in the neighbourhood of Montpellier contain microzymes, which convert cane-sugar into alcohol and acetic acid, without any trace of butyric acid. The earth from moors, which is used in the Jardin des Plantes at Montpellier, contains a number of microzymes together with bacteria, and gave rise, when added to a solution of starch, to alcohol, sodium acetate, butyric acid, and calcic lactate. The dust from the streets of Montpellier gave rise, under heating with water, to a quantity of hydrogen and of carbonic acid. A small cat was interred in chalk, and it was found that the difference between its microzymes and those of the chalk itself, was that the former "easily gave rise to bacteria, while those of the chalk did not change their form." The author thinks this last experiment is of significance, as indicating that the microzymes found in chalk, rocks, earth, street dust, &c., have no other origin than the microzymes which make "an integral part" of every living organism, and whose physiological duty is, after death, to destroy the organism.

M. Béchamp points out in a foot-note that M. Pasteur has confirmed the statement as to the existence of microzymes in earth though not in the chalk, while MM. Chamberland and Roux deny the existence of *M. cretæ*, which they trace to an experimental error.

## Algæ.

**Fructification of Chætopteris plumosa.**‡—In a previous communication on this subject,§ R. Wolny suggested that the unilocular sporangia of this seaweed, described by Areschoug, might possibly be merely multilocular sporangia arrested in their development. Further examination of specimens of the alga obtained from Spitzbergen shows that there are two kinds of unilocular sporangium, differing greatly from one another in their mode of development; the multilocular sporangia exhibiting the division into compartments from their very earliest stage of development. The function of these various structures in relation to reproduction requires further examination.

* See Louisville Med. Her., iii. (1881) p. 27.
† Comptes Rendus, xcii. (1881) pp. 1344–7.
‡ Hedwigia, xx. (1881) pp. 42–4.
§ See this Journal, iii. (1880) p. 678.

**Variegation and Cell-multiplication in a Species of Enteromorpha.***—Mr. P. Geddes found on stones in a sea-water aquarium in the laboratory at South Kensington, a curious little alga, identified by Dr. Bornet as a species of *Enteromorpha.*

Viewed with a lens, the fronds are of a beautiful green, often more or less mottled with white, and a 1-inch objective shows among the ordinary green cells, others which are smaller and colourless, occurring singly or in patches of very variable size. Oftener than these variegations of the frond itself, one notices buds, or even large branches, completely colourless. And the extreme case—of whole tufts, almost without any green cells—is not wanting.

These phenomena are not due to an etiolation of green cells, for the colourless cells are oftenest apical, and colourless shoots are to be seen projecting clear above the tangled mass of other Algæ, by which the specimens are always more or less surrounded, while the portion of the frond thus shaded may be of the deepest green. Moreover, specimens kept growing for months, exposed to direct sunlight for several hours daily, never lost their variegated aspect; nor did those kept in darkness show any distinct increase in the proportion of white cells to green.

On a closer examination of the colourless buds, Mr. Geddes found that, at one side of the frond or filament, and generally midway between two green cells, there is often a slight prominence of cellulose enclosing a tiny droplet of colourless, non-nucleated, hyaline protoplasm. In a further stage are two similar but larger masses, and so on up to a comparatively long row of colourless nucleated cells, a series of gradations which shows that the colourless shoot arises in a way totally distinct from that by which the ordinary green cells are developed. The transparent cells multiply by transverse division, and have also the power of developing chlorophyll. While the majority of the colourless shoots are sharply marked off by their colour and general appearance from the green part of the frond, others are to be found in which there is a gentle gradation from white cells to green, the development of chlorophyll beginning at the base of the shoot, and proceeding upwards. The multiplication of the green cells by transverse division is obvious; but it is by no means easy to account for the origin of the colourless cells.

The cellulose of an Alga possesses a *capsular* structure. A cell throws out a coat of cellulose, and then divides into two new cells; each developes its own investment of cellulose, and these lie end to end within the first. The extremities of these new cells being biconvex, they are not in complete apposition, but an angular interspace is left which extends ring-fashion round the filament. It is not to be expected that these laminæ of cellulose should be of precisely equal thickness and strength throughout, nor of equal permeability to fluid; and Mr. Geddes, therefore, considers that, where a weak place in the cellulose wall happens to come opposite the intercellular space, a certain amount of water might easily enter the latter from the cell;

* Trans. R. Soc. Edinburgh, xxix. (1881) pp. 555–9 (1 pl.).

this water might soften and swell the circumjacent cellulose, and thus protuberances of the cellulose *alone* would easily arise. But if instead of a mere exosmose of water through the wall, the growing protoplasm be supposed to force a passage into the intercellular space, a reasonable explanation is afforded of the origin of the tiny drops of colourless protoplasm. Their position and form are strong proofs of their origin in this way. Such buds arising as they would from the colourless ectoplasm of the green cell, would necessarily be themselves colourless. This hypothesis may be verified by direct observation.

Thus we have two distinct modes of cell-formation simultaneously in progress—the ordinary vegetative process by transverse fission and a process of gemmation.

**Fallacious Appearances in Fresh-water Algæ.***—F. Wolle points out that in *Conferva floccosa* and *fugacissima* and *Microspora vulgaris* the cell-contents frequently swell out into a globular form, the envelope of the filament swelling up at the same time, thus presenting a deceptive resemblance to similar conditions of *Ulothrix* and *Hormospora*. *Hormiscia moniliformis*, *Hormospora purpurea*, and *H. Hobbyi* exhibit a similar characteristic, and present each a close resemblance to the fragmented condition of *Conferva* and *Ulothrix* that they might readily be regarded as identical. *Conferva punctalis* has a condition of this kind, which might correspond to a good species of *Glœotila*.

**Absorptive Organs of Batrachospermum.†**—M. Sirodot states that it is a general law in the lower orders of vegetable life that absorption is not effected by all the cells, but only by certain ones provided for this purpose with very thin cell-walls. In the case of resting reproductive cells the period of quiescence is marked by a strong thickening of the cell-wall, the rupture of which inaugurates a new period of activity.

In the Batrachospermeæ the thickening of the cell-walls is accompanied by anatomical changes. In the primary axes the transverse cell-walls do not thicken equally over their whole surface; in the central point they retain their primitive character, or even disappear, as is shown by the coagulation of the protoplasmic substance, the protoplasmic contents of two contiguous cells becoming united by a filiform connection which runs through the transverse wall. At the same time that this communication is effected, the special organs of absorption make their appearance, radical filaments growing from the base of the thickened cells. The absorptive function of these filaments is, however, temporary only; they ultimately become organs of attachment.

This structure has its simplest development in the non-sexual form or *Chantrausia;* in the sexual form or *Batrachospermum* it is much more complicated. In normal circumstances the internodes are partially or entirely covered by descending articulated filaments, which continually increase in number, and which grow at first from the basal cell of the fasciculated branches that constitute the

* Amer. Mon. Micr. Journ., i. (1880) pp. 21–2.
† Comptes Rendus, xcii. (1881) pp. 993–5.

nodes or whorls, afterwards from the base of the fasciculated ramifications, and very often from the base of the branches, where nutrition is shown by the greater activity, especially of those which bear the fertile glomerules.

The physiological function of these articulated filaments varies with their age, their structure, and their position on the basal or median portions of the axis. When young they are before all absorptive organs; as is shown by the fact that if the young plant is immersed in any substance which prevents absorption they disappear, and spring again from a more favourable spot. At a later period, when their walls have become thicker, the lower ones become organs of fixation, while the upper ones constitute the cortication which adds to the strength of the axis, through the hardening of an interstitial gelatine.

The apices of the verticillate branchlets present a peculiar appearance. In general, when a vegetable cell with thin walls dies, it first becomes inflated, then bursts and disappears. On detached apices the dead cells undergo a contraction to as little as one-fifth of their original dimensions.

**New Zealand Desmidieæ.***—Mr. W. M. Maskell has published a list of the Desmidieæ found in New Zealand, containing sixteen genera and sixty species, of which six are new or undescribed, viz. *Aptogonum undulatum*, *Micrasterias ampullacea*, *Didymocladon stella*, *Docidium dilatatum*, *Triploceras tridentatum*, *Closterium selenæum*; two species of *Ankistrodesmus* could not be identified.

In justification of the creation of the new species (only one new species of diatom having for several years been described from New Zealand), Mr. Maskell, while recognizing that "the lower forms of life, particularly pond life, seem to be pretty much the same all over the world," justifies the creation of the new species on the following grounds. "Although the actual following out of the process of *conjugation* may be difficult or perhaps impossible, I take it that when on several occasions the process of *division* is to be observed; when in such cases the resulting frond is identically similar to other and frequently seen fronds; when there is also at different times of the year, and perhaps in different years, complete similarity in the specimens examined; and when no trace can be found, in descriptions of species by authors, of fronds having the same characters,—there is at least very strong evidence that the plants under review form a definite species different from the known species. To use Mr. Archer's words,† 'Constantly recurring identical forms must be assumed to be the descendants of similar progenitors.' Moreover, division, as I imagine, can only take place in mature fronds—immature plants could scarcely propagate; consequently any plant seen in process of division must, if no previous record of its characters can be found, be taken as new. For these reasons I have ventured to set down a few plants as new species, and not merely as varieties."

* Trans. N. Zealand Inst., 1880, pp. 297–317 (2 pls.).

† Quart. Journ. Micr. Sci., ii. (1862) p. 238.

As to the preservation of desmids, Mr. Maskell has found no fluid which is entirely satisfactory, but, "taking them all round, he believes that of all preservative fluids glycerine is the best."

**Division of Closterium intermedium.***—J. Schaarschmidt describes the mode of division in this desmid, which is similar to that of *Penium interruptum*. The cell has a primary suture, and a secondary suture in the middle of each hemicyst. Beneath these are formed the new cell-nuclei, which are in all probability daughter-nuclei of that of the mother-cell. The cell-wall of the mother-cell then ruptures along the primary suture; the daughter-cells rapidly attain their full size and separate from one another. The secondary sutures are analogous structures to the "caps" of *Œdogonium*. Before each division the cuticle is raised from the cell-wall in the form of a hollow ring, which ruptures when the division takes place, while the very plastic cell-wall extends rapidly. The number of secondary and tertiary sutures may be very large, up to twenty-four, indicating the number of times that the individual has divided. The author is of opinion that all the species of *Closterium* with secondary sutures divide in this way, as well as in the ordinary way.

**Schmidt's Atlas of the Diatomaceæ.**—We understand that the publication of this work is to be resumed, and that two further parts are just ready for issue. The other four will, it is hoped, appear in October.

**Van Heurck's Synopsis of Belgian Diatomaceæ.**—Part III. of this work † is now published, containing the first portion of the Pseudo-Raphideæ (plates 31-33).

**Delogne's Belgian Diatoms.**—M. C. H. Delogne, assistant naturalist of the State Botanical Garden at Brussels, is issuing a series of preparations of Belgian diatoms. The nomenclature adopted is that of Van Heurck's 'Synopsis,' and that author has revised M. Delogne's determinations, or identified the forms by the types of his own collection. They are "enclosed in an elegant and solid box, having the appearance of a book, and can be placed on the library shelves."‡

**Peculiar Structure of Isthmia enervis.**—Mr. W. S. Kent records § a remarkable internal structure in the unicellular frustules of this marine diatom, examined in the living state. The characteristic olive-brown cell-contents, or endochrome, was found to be collected for the most part into a more or less extensive central spheroidal mass, from which radiating and frequently branched granular, thread-like prolongations of the same substance extended to and united with the periphery. Submitted to high magnifying power (700 diameters), both the central mass of endochrome and its radiating prolongations were shown to be composed of an aggregation of minute brown, ovate

* Magy. növénytani lapok, v. (1881) pp. 3–6. See Bot. Centralbl., vi. (1881) p. 1.

† See this Journal, iii. (1880) p. 687.

‡ Cf. Brebissonia, iii. (1881) pp. 156–7.

§ Kent's 'Manual of the Infusoria,' i. (1880) p. 59.

or spindle-shaped corpuscles immersed in, or held together by, a colourless and more fluid plasma. In the radiating and reticulate extensions from the central mass these corpuscles were sometimes quiescent, but more often were seen travelling in slow and regular order to and fro between the centre and the periphery; the general aspect under these conditions corresponded so nearly with the characteristic granule circulation of certain Foraminifera and other Rhizopoda, that it was difficult to realize that it was a unicellular plant, and not a Protozoon, under examination. In the most actively moving cells, almost the whole of the ovate corpuscles were deployed upon, and in motion along, the radiating filaments, while in the most quiescent examples both filaments and corpuscles were withdrawn into the central mass.

**Motion of Diatoms.***—Mr. J. D. Cox considers that before any satisfactory solution of this problem can be reached, or any decisive determination whether the motion be due to osmotic or to ciliary action, a good deal of patient observation must be made—both of the motion itself under varying circumstances, and of the structure of the diatom, including the nature of the raphe, and the question of the existence of a gelatinous envelope covering free as well as stipitate frustules.

The following observations, which have recently been repeated and fully verified, are copied from notes made in the summer of 1879, and are a contribution to the record of facts which any sound theory on the subject must account for. They seem most consistent with a supposition of ciliary action, though it is possible that some form of osmotic action might produce similar phenomena.

A fresh gathering of diatoms from a little brook near Cincinnati, contained a number of *Nitzschia linearis*, which had progressed so far in self-division that the front view of the frustule was twice as broad as the side view, but from the peculiar form of the *Nitzschia*, the carina was in plain view on each edge of the frustule as it lay or moved on its broader side. The first case Mr. Cox noticed was that of a frustule apparently held fast by the glasses of the compressor, but a gelatinous mass of decomposed vegetable matter was seen moving steadily along the frustules from one end to the other, making a momentary halt in the middle. The mass was as large in diameter as the width of the diatom, so that it reached from side to side of the frustule, overlapping the carina of the valve on one side. The motion of the loose matter was once or twice reversed, as if the diatom was trying to back out of its position, and so produced a current in the opposite direction. Presently the diatom got loose, backed out and moved a considerable distance across the field, the gelatinous substance still adhering and being dragged after it. Again an obstruction was met, the diatom stopped, and as if the machine were reversed in the new effort to back out, the foreign matter was again dragged to the foremost end, and this time a smaller floating particle of similar kind moved in the same manner along the opposite

* Amer. Mon. Micr. Journ., ii. (1881) pp. 66–9.

valve of the frustule. In an effort to make the diatom roll over, so as to make more sure of its species, it was swept out of sight and lost.

A little later some fresh samples of similar material afforded a repetition of the phenomena, and confirmation of the facts. A frustule of the same species as the former was so wedged in the compressor that one end was free, while the other was fast. The free end would move vigorously one way or the other, in an arc of a circle, but the diatom was not released. Attached to it were two gelatinous masses, one on each side, and of similar size to those described in the former case. These were distinctly applied to the valves so that, as the diatom lay in front view, as before, the two masses were on the opposite side of the frustule. These masses moved along the sides, sometimes the whole length of the diatom, sometimes only to the middle, where they would rest awhile, and then either complete the motion or go back. They did not always move simultaneously, nor with the same speed, but with a general agreement of motion. This action was continued half an hour, the diatom not getting free.

Turning to another part of the slide, another free-moving specimen was found with a similar gelatinous mass in contact with it. The diatom was moving freely and towing the matter along with it, attached to its hinder end. Soon the mass began to move forward on the shell, the motion of the diatom ceased and was presently reversed, the order of sequence being distinctly as stated. In several instances the motion of the gelatinous mass from the rear end of the diatom forward, plainly preceded the change in the direction of the frustule, as if the change of ciliary motion (assuming that to be the motive power, for the sake of illustration) did not instantly stop the headway of the diatom, but required an appreciable moment of time to overcome the momentum. The observation of this shell continued for a full hour, the changes of direction being frequent, and all the accidental modifications and phases of the phenomena were strikingly confirmatory of the existence of some force applied along the line of the raphe, acting sometimes in one direction and sometimes in another, in such a way as would be fully explained by supposing ciliary action along that line, but which do not seem to be so easily accounted for by osmotic action, certainly not by osmotic action at the ends of the frustule.

On one or two occasions the acting force did not appear to be reversed at the same instant at the two ends of the diatom. Twice the foreign matter moved against the current of general motion, slowly, it is true, but really in such a way as to indicate that the force acting upon it was not in the same line of direction as was that exerted on the other half of the frustule. But when the motion controlling the gelatinous mass became vigorous, it either was dominant or was indicative of harmonious action at both ends of the shell, so that the motion of the diatom through the water became very pronounced and strong.

Mr. Cox looked for similar phenomena among the other kinds of

diatoms in the gathering, but saw nothing of the sort except in the instances described. The *Naviculæ* were very lively, but he saw no examples of action upon foreign matter that came in their way. Neither could he detect any current, even along the *Nitzschias;* the motion of the gelatinous substance occurring only when it came in contact with the shell and apparently adhering to it.

The study of the diatom-shell has led the author to accept the opinion that the raphe is a real fissure in the shell, but in many species it is not a simple and vertical linear-opening of the shell. It is more like the joint formed by the overlapping of the edges of curved tiling on a roof: a thickened line of silica borders one lateral half of the shell, while the other half dips under it with a thin film. It is true that an osmotic force may be conceived as working along the raphe, as well as that a line of cilia should do so; but the difficulty is to account for such action upon an extraneous mass as that described, or to make osmosis from such a place upon the shell move the diatom in the direction of its length. The assumed presence or absence of a gelatinous film enveloping the diatom does not materially vary the conditions of the problem in either case. If we assume that the osmotic action is at the extremities of the shell, the observed phenomena, as to the action upon the gelatinous mass when in the middle of the frustule, are unaccounted for.

As to the manner in which the lapping of the halves of the frustule along the raphe is effected, it may be most easily seen in some of the coarser *Pleurosigma*. In broken shells of *P. attenuatum* and *P. formosum*, it was seen very plainly demonstrated. Sometimes the thickened line of silex which borders one-half of the frustule will be found sticking out alone, the thinner part of the shell being broken away from it. Sometimes it will be in its normal position, but the lateral halves of the shell will be separated by pressure, so as to show on one side the thick edge, and on the other the fitting gutter caused by the projection of a thin lip. Occasionally also a cross fracture of the shell will be found on a broken fragment, in such position that we get the benefit of a cross section, and see the whole joint in the form described.

## MICROSCOPY.

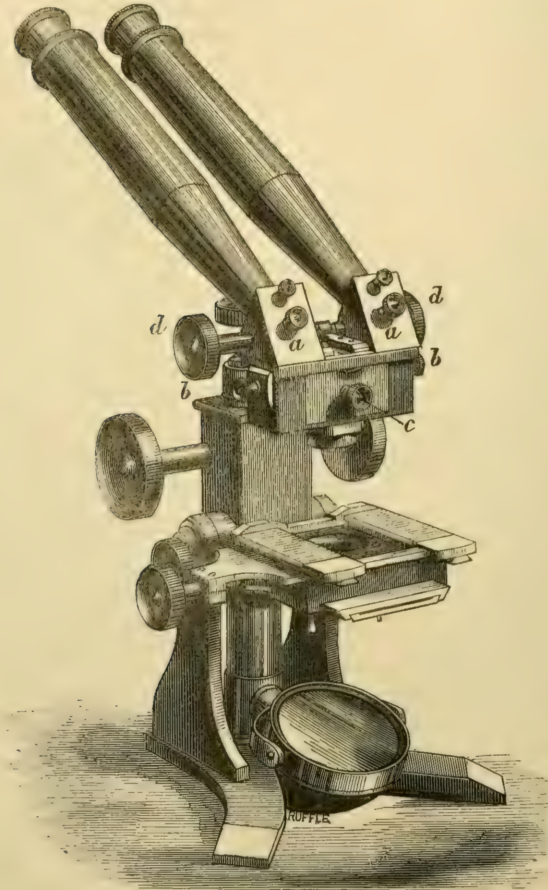
### α. Instruments, Accessories, &c.

**Ahrens's Erecting Binocular Microscope.**—Fig. 135 shows a form of erecting binocular devised by Mr. C. D. Ahrens. The Microscope as figured is intended only for use with low powers, as there is no fine adjustment.

A sliding-box *c* contains two Wollaston prisms (such as are used for the *camera lucida*); *b b* are similar boxes containing each a right-angled prism; *a a* each contain a truncated equilateral prism that directs the image pencils up the respective inclined tubes; *d d*

are milled heads acting on a pinion fitted with right- and left-handed screws working together, by which the body-tubes and *a a* can be set wider or closer to suit the distance of the observer's eyes.

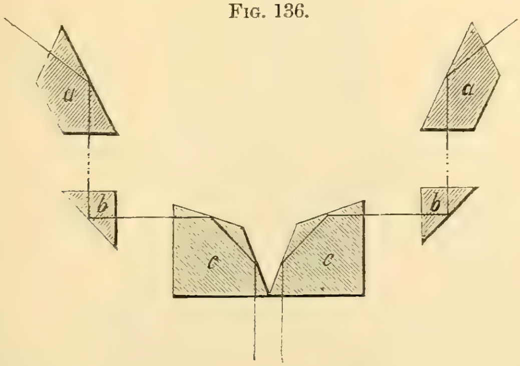
Fig. 135.




The action of the prisms may be understood from the diagram (Fig. 136). *c c* are the two Wollaston prisms placed close together as figured, so that each may receive one-half of the pencil from the objective; by two internal reflections in each prism the rays are thrown into the right-angled prisms *b b*, from the long surfaces of which they are again totally reflected to total reflecting surfaces of the truncated equilateral prisms *a a*, and thence up the tubes. In the diagram *a a* are shown in vertical section, but in actual use in the Microscope, the reflecting surfaces, relatively to *b b*, would direct the rays from

the vertical 60° backwards—that is to say the prisms *a a* are turned $\frac{1}{4}$ round on their bases in the diagram to show the direction of the rays. In future constructions, Mr. Ahrens thinks the prisms *a* and *b* should be cemented together.

Fig. 136.




We fear that this Microscope cannot compare with the simplicity of the Wenham and Stephenson models, or even with those which have been previously devised by Mr. Ahrens himself.

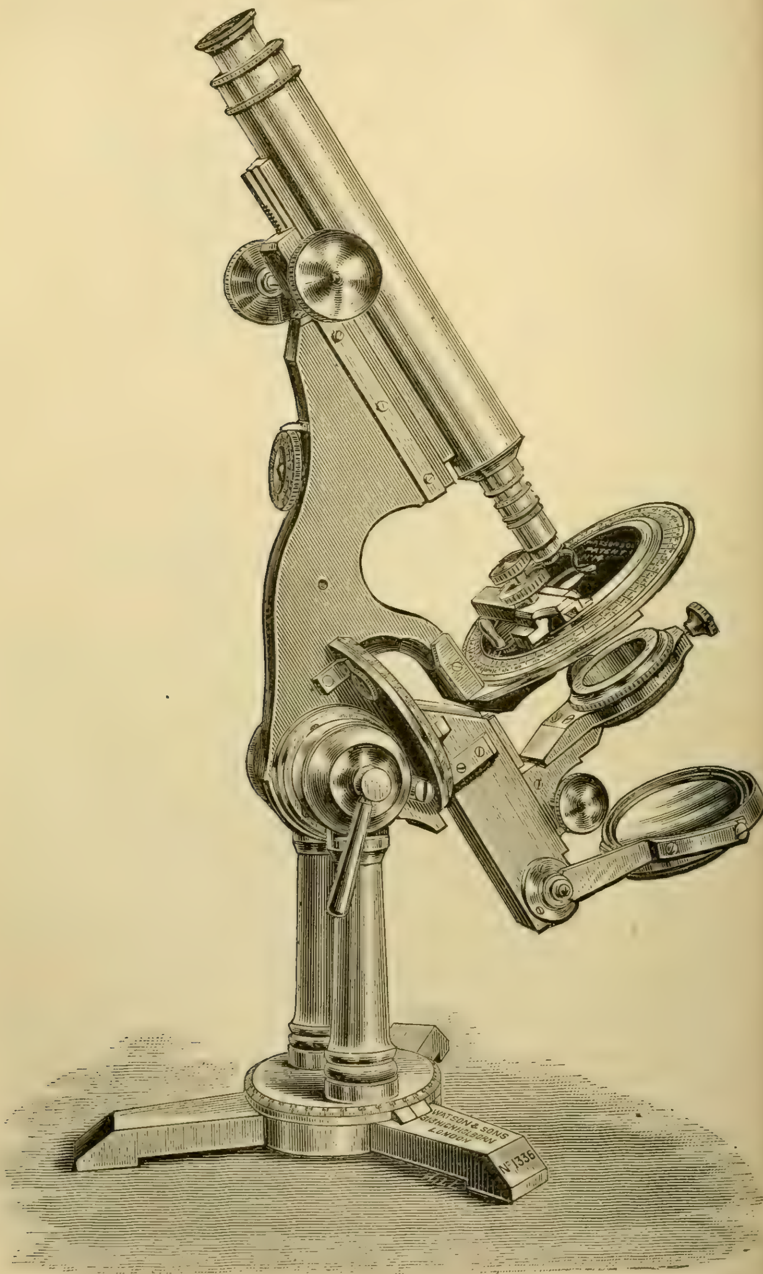
**Crossley's Microscope with Special Arrangement for Illuminating the Swinging Substage.**—This arrangement is the design of Mr. Edward Crossley, F.R.A.S. A general view of the Microscope, as constructed by Messrs. Watson, is given in Fig. 137, and Fig. 138 shows in section the prisms used for the illumination.

The light from the lamp is thrown into the hollow horizontal axis of the Microscope with the aid of the bull's-eye condenser, and by a prism placed in the centre of this axis, is reflected forwards in the direction of the axis on which the swinging substage turns. The arm of the swinging substage is made in the form of a box, and carries a second prism in the axis on which it moves, so as to intercept the rays of light coming from the first prism and reflect them in the direction of the arm or box. At the end of the box is a third prism, which throws the rays of light forward on to the mirror, by means of which they are finally directed to the object on the stage.

In Fig. 138, A is the first prism, as seen in vertical section in the centre of the horizontal axis. B is the second prism in the axis of the swinging substage. C is the third prism at the end of the box arm of the swinging substage. D is the mirror, and E is the stage carrying the object. The dotted line represents the direction taken by the rays from the lamp.

It will thus be seen that no change in position of the Microscope on its horizontal axis affects the direction of the light from the lamp, and also that whatever the position of the swinging substage, whether above or below the stage, the illumination remains constant upon

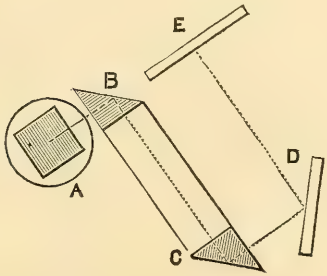
Fig. 137.



the object. Thus the greatest facility is given for illuminating the object at any angle, and seeing which is the most suitable.

The prisms used are 1 inch, and give sufficient light for a $\frac{1}{16}$-inch

FIG. 138.




object-glass with a Ross BB eye-piece, using of course a suitable condenser beneath the stage. The field of a 4-inch object-glass is also fully covered. It would be better to use prisms a quarter of an inch larger for the highest powers.

**Griffith Club Microscope.**—We gave a description and three figures of this Microscope on pp. 293–6, and have since received a communication from Mr. Griffith stating that sundry minor modifications have been made in the construction, which have improved the general steadiness of the movements.

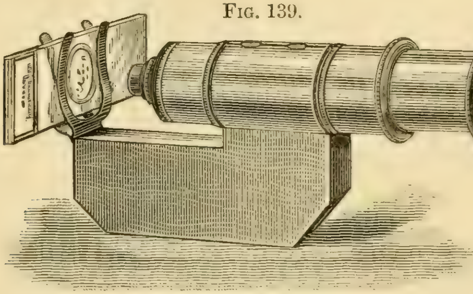
The form of the tube carrying the stage has been changed by adding rectangular longitudinal flanges on opposite sides, modifying the corresponding fitting accordingly. A spiral spring has also been inserted, by which the bearings are kept in closer contact. These alterations give a smoother motion to the fine adjustment, and also provide more substantial support for the stage. The pin sliding in the spiral-grooved nut (by which the fine adjustment is effected) has been split and sprung, so that it now fills the cross-section of the groove, preventing lost motion and diminishing the lateral leverage that formerly obtained in moving the stage. The gauge of the optical-body has been enlarged to permit the use of eye-pieces of larger diameter. A movable wheel of diaphragms has also been added beneath the stage.

**Parkes's Child's Portable Compound Microscope.**—In this instrument (Fig. 139) the principle embodied in what are known as "demonstrating" Microscopes has been applied (by Messrs. Parkes) to a very cheap form of instrument sold (with a 2-inch object-glass, six objects, and two glass slips with hinge for temporary mounting) for a very few shillings.

We are inclined to think that this form might advantageously be

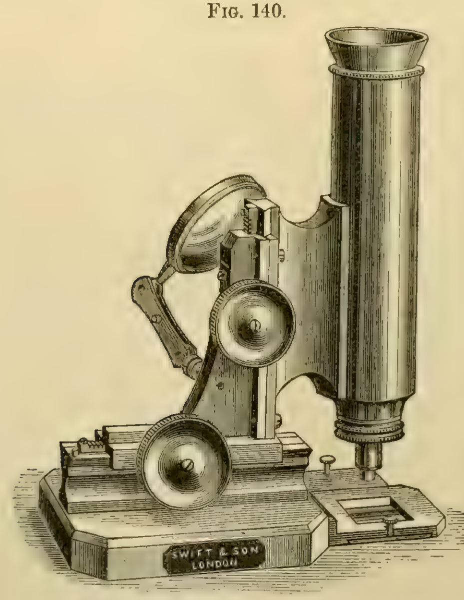
adopted in the case of more ambitious instruments, particularly those which are intended for field work.

Fig. 139.



**Silk-Mercer's Microscope.**—This instrument, for determining the quality of silk and other fabrics, is made by several opticians, the particular one shown in Fig. 140 being that issued by Messrs. Swift.

Fig. 140.




Its general form sufficiently appears from the figure. In addition to the usual rack-and-pinion focussing movement, the body can be moved from front to back and *vice versâ* by a second rack and pinion, lateral motion being obtained by shifting the whole instrument.

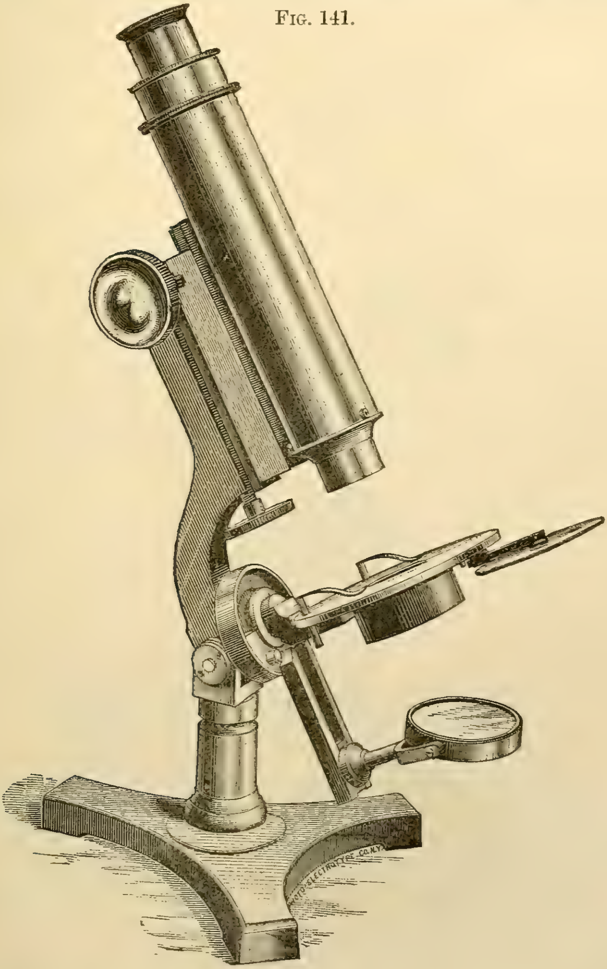
In the projecting piece in front of the base slides a lower plate,

with two square openings of different sizes, which can be brought successively over the silk under investigation, so that, as with the ordinary "linen provers," areas of known extent may be under observation, and the number of strands to the metre or yard counted.

The eye-piece has a conical cap for shutting off extraneous light.

**Sidle's No. 4 "Acme" Microscope.**—Messrs. Sidle (U.S.A.) have brought out a still simpler Microscope than the one figured and

Fig. 141.



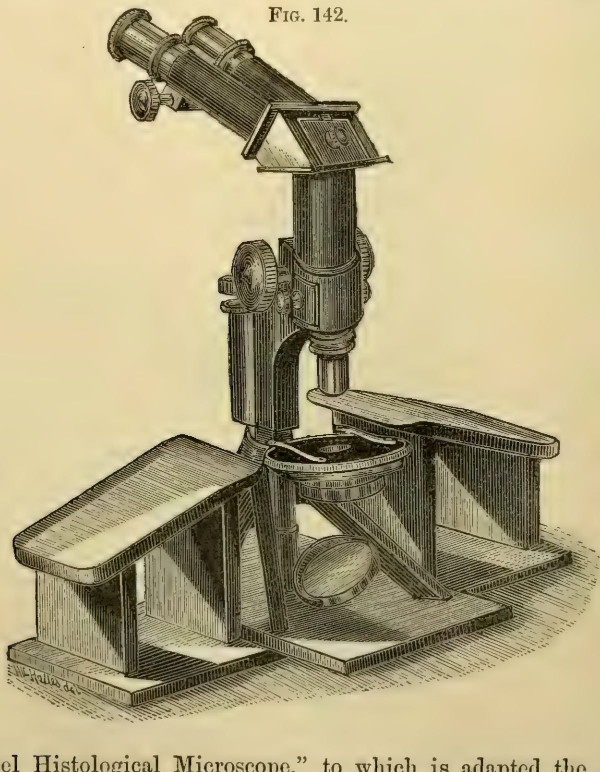
described in vol. iii. pp. 522–3, embodying the swinging substage with a minimum amount of "luxuries and intricate non-essentials."

The stand is shown in Fig. 141 (body $6\frac{1}{2}$ inches long and $1\frac{1}{3}$ inch

diameter, and with a draw-tube). The fine adjustment moves the entire body by means of a micrometer-screw at the *lower* end, and within the bend of the limb, and is claimed to be "practically frictionless, acting on rollers, and perfectly free from lateral movement." The mirror slides upon a radial arm that swings laterally in a travelling zone in a metal disk, the centre of which is in the plane of the object. For opaque illumination the mirror-bar can be swung above the stage. The wheel of diaphragms fitting beneath the stage is mounted on a jointed arm allowing it to be turned aside clear of the stage opening, a fixed stop ensuring its being in the axial position when so required. The circular stage ($\frac{1}{8}$ inch thick), with standard screw in central opening, has spring clips, which may be used under the stage when great obliquity is required. A sliding substage to be attached to the mirror-bar can be substituted for the accessory tube.

**Baker's Students' Stephenson's Erecting Binocular Microscope.**—This instrument (Fig. 142) consists of the stand of the small

FIG. 142.

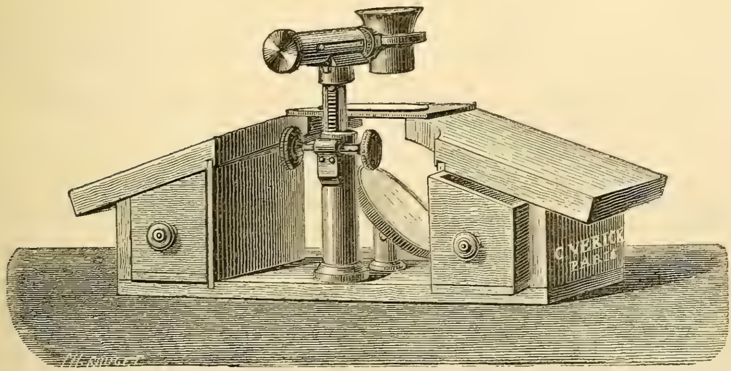


"Model Histological Microscope," to which is adapted the optical part of a "Stephenson's Erecting Binocular," the whole being placed

in the centre of the base of a "Baker's Laboratory Dissecting Microscope" for giving the requisite support to the hands in dissecting on the stage. An ordinary monocular body can be readily substituted for the binocular when desired.

**Vérick's Dissecting Microscope.**—This instrument (Fig. 143) does not differ in a sufficiently marked manner from the usual form (though we have found it to be extremely conveniently arranged) to require it to be noticed here, but a special advantage to which we think attention may be usefully drawn is the mounting of the lenses, which are fixed in a tubular setting of more than ordinary depth and

Fig. 143.



expanded at the top to receive the eye—similar, in fact, to a watchmaker's glass. We are not able to say whether this additional depth would in prolonged examinations develope any disadvantages; but so far as we have had the opportunity of judging, it constitutes a specially effective protection to the eye from extraneous light beyond what is obtained in the case of the more ordinary setting.

**Gundlach's "Periscopic" Eye-pieces.**—We have been asked for a description of these eye-pieces, one of which was shown at a recent meeting of the Society. The following description is by Mr. Gundlach himself: *—

"The Huyghenian eye-piece in its original construction consists, as is well known, of two plano-convex lenses, of which one, the 'field-lens,' has three times the focal length of the other, the 'eye-lens'—the distance between the two being equal to double the focal length of the eye-lens, the plane side of the field-lens facing the convex side of the eye-lens.

"The field-lens not only widens the field of view, but also corrects the spherical as well as the chromatic aberration, as it is placed beyond the focal distance of the eye-lens (the actual eye-piece), and in consequence thereof acts negatively to the same.

* Appended to a Catalogue of Microscopes.

"This correction, however, is not a complete one; for, with the most favourable distance between the two lenses, a not inconsiderable remnant of the chromatic aberration still remains, while the spherical aberration is already correspondingly overcorrected. The first is noticeable by the blue edge bordering that side of the object which is turned towards the centre when the object is placed towards the edge of the field. The remnant of the spherical aberration causes the distortion and want of sharpness of definition at the edge of the field. By increasing the distance between field-lens and eye-lens the blue colour may indeed be made to disappear, but the spherical aberration increases correspondingly, and the field is narrowed considerably. If, on the contrary, the field-lens is brought closer to the eye-lens, the spherical aberration is certainly diminished; but, notwithstanding this, the image at the edge of the field does not become any more sharply defined, because the chromatic aberration has increased in equal ratio.

"One advantage, however, is gained by approaching the field-lens closer to the eye, namely, a considerable widening of the field.

"If, under these circumstances, the aberrations of the eye-lens are corrected by suitably composing the same of flint- and crown-glass, we have an eye-piece which, with all the advantages of the Huyghenian eye-piece, surpasses the latter by having a larger field.

"These facts form the basis of the construction of the Kellner orthoscopic eye-pieces. Kellner brought the field-lens into the focus of the eye-lens, made the latter achromatic, and chose such curvatures as to remove also the spherical aberration, and showing a flat field, for which latter purpose he also transformed the plane convex field-lens into a double convex one.

"The simultaneous accomplishment of all these results was favoured by the circumstance that in approaching in a Huyghenian eye-piece the field-lens to the eye-lens, the spherical aberration diminishes more rapidly than the chromatic. The preponderance of the latter over the former in the Huyghenian eye-piece must therefore admit of being equalized at a certain point, or rather must accommodate itself at this point to a similar disproportion in the achromatic eye-lens. This point, however, is, as in the Kellner eye-piece, almost exactly the focus of the eye-lens.

"A further approach of the field-lens to the eye-lens (bringing the latter within the focus of the former) again gives the preponderance to the chromatic aberration, and an equalization by an achromatic double lens becomes impossible under the circumstances.

"If, however, such further approach should be possible without such or other disadvantages, it would be very desirable, not only on account of the enlargement of the field which it would cause, but also the circumstance that when the field-lens is in the exact focus of the eye-lens, every fine particle of dust on the former is clearly visible and sharply defined, greatly interfering with the observation.

"These facts and considerations caused me to reflect whether a triple eye-lens (consisting of two positive crown-glass lenses, and one negative flint-glass lens) instead of a double lens would not better

answer the conditions; and I have in consequence succeeded in forming such a lens, which answers the purpose in a very high degree.

"My new 'Periscopic eye-piece' consists of a triple eye-lens, a double convex field-lens, the latter being situated within the focal distance of the former, and a diaphragm, located in the focus, of the equivalent of both lenses.

"The field of the new eye-piece is considerably larger and flatter than that of Kellner's, and the image is sharply defined to the extreme edge.

"As the focus of the eye-piece lies behind the field-lens (the same as in Ramsden's eye-piece), it is particularly suitable for micrometers, especially as the divisions are distinctly, and in correct proportion, visible to the extreme edge, which is notably not the case with Ramsden's eye-piece.

"A micrometer division, placed in the focus of the eye-piece, shows, moreover, very perspicuously the high degree of the correction of the aberrations, while the image transmitted by an objective can be no reliable test, as the aberrations of the objective, especially the distortion, are easily confounded with those of the eye-piece."

**Nachet's Objective Carrier.**—Every working microscopist has desired a ready means of varying his objectives without the trouble of unscrewing one objective and screwing on another. This difficulty has been partly met by the use of the "nose-piece"; but this cannot be made conveniently (at least in the case of the heavily mounted English objectives) to carry more than two powers.*

FIG. 144.

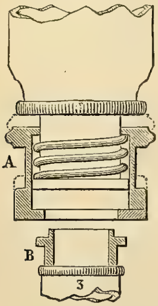
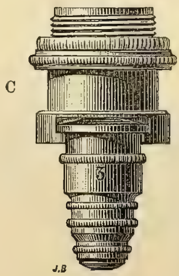



FIG. 145.




The attention of M. Nachet having been long directed to this point, he has recently brought out an improved form of his "porte-objectif" (originally made on a suggestion of Professor Thury) which allows the change of objectives to be readily made without as much raising of the body from the stage as is required in screwing and unscrewing.

It consists (Fig. 144) of a fixed inner cylinder, whose top screws into the bottom of the body, this being embraced by a movable outer

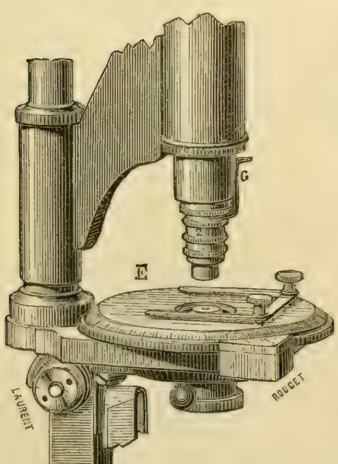
* See Carpenter's 'The Microscope, &c.,' 6th ed. (1881) pp. 856–7 (2 figs.).

cylinder A, that is kept closely pressed up to its lower end by a strong spiral spring between the two. The bottom of this outer cylinder is formed by a shoulder that is cut away for about one-fourth of its circumference, so as to allow a collar B, at the top of the objective to be slipped into the opening as shown at C (Fig. 145). When this is done, the objective is held firmly in place by the pressure of the spring; and all that is needed to remove it is a slight pulling down of the outer cylinder, which enables the collar of the objective to be slipped out again. The inner cylinder can have the Society screw; and the "collar" can be adapted to receive either M. Nachet's or any other objectives.

Having been enabled to make a trial of this little apparatus, Dr. Carpenter is "glad to be able to speak most favourably both of its simplicity and its effectiveness."

**Vérick's Objective "Extractor."**—This (Fig. 146) is also a contrivance for readily attaching and removing the objective, and which is in principle an adaptation of that of M. Nachet. The nose-piece (which screws into the body) has an outer tube somewhat shorter, to which is attached a semicircular "fork" projecting at right angles at the bottom. The outer tube is ordinarily pressed back by an internal spring, which brings the fork against the lower end of the nose-piece. On pressing the catch G which forms part of the outer tube, the latter descends, and the fork is separated from the nose-piece. The objective E, which has a wide collar, can then be slipped into the fork, and on releasing the tube the fork, with the objective, is drawn back by the spring. A short cylindrical piece projecting above the collar of the objective fits into a corresponding aperture at the end of the nose-piece, and thus secures accuracy of centering.

Fig. 146.




Whilst this apparatus undoubtedly allows a change of objectives to be made with the utmost rapidity, we find that the objectives are not retained in position with sufficient firmness, slight pressure being sufficient to deflect them laterally; this is especially noticeable in using an objective with "correction" collar.

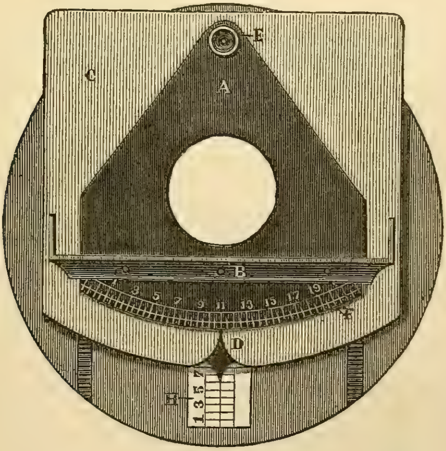
**Sliding Objectives.**—A modified method of accomplishing this object * is applied by Messrs. Parkes to a very cheap form of instrument. The end of the body-tube terminates with a smaller sprung

* See this Journal, iii. (1880) p. 1048.

tube about $\frac{3}{4}$ inch long and $\frac{1}{2}$ inch diameter, and into this the objectives (which are of correspondingly small size) slide direct. It is said that "by this plan the following important advantages are obtained: the object-glasses are more quickly and easily changed; the rack may be more uniformly worn by sliding them in at different distances; and should any portion of the rack be broken or deranged at the focussing points, the object-glass may still be used by sliding it in or out as may be required."

**Smith's Object Plate and Finder.**—The following note was read by Mr. James Smith at the May meeting of the Society:—"In the October number (1880) of the Journal of the Society, pp. 880–1, a very simple form of stage is described by Messrs. Schmidt and Haensch. It appeared to me that the use of a graduated arc for a finder was so effective that it might be easily and usefully applied to some English Microscopes; and in the following description and accompanying drawings, I have endeavoured to carry out the idea.

FIG. 147.



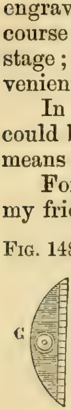

The only piece of apparatus required, where there is a good stage-plate (moving vertically) to which it can be applied, is a thin piece of metal somewhat of the shape A moving on a centre E by means of a small screw on the stage-plate; the bottom of the piece is cut into an arc of a circle, of which E is the centre, and upon this arc are graduated the divisions. Attached to this plate is an object-holder B. The only extra thickness interposed between the object and the source of illumination is that of the graduated plate (about $\frac{1}{30}$ of an inch). In the case of my own Microscope, where the stage-plate is not convenient for the purpose, the finder-plate is screwed to another thin plate C, as in the drawing, which slides vertically on the concentric stages. At the foot of this plate C is engraved or painted a small double pointer D, to read off the position of the graduated arc,

and also the vertical divisions upon a small scale attached to or engraved upon the lower stage-plate H. This vertical scale can of course be placed in any other position either at the side or top of the stage; but I think the position I have indicated is the most convenient one.

In the case of a mechanical stage, the vertical screw movement could be used, the horizontal one being brought to a fixed position by means of a line marked upon it.

For use with a Microscope with a stage moving in all directions, my friend Mr. J. D. Hardy, of the Quekett Microscopical Club, has a small but ingenious addition to make this finder useable. In one of the small circular openings in which the stage-plate moves, he attaches a piece of metal G, Fig. 148, by means of a screw. This serves at once as a vertical scale and also makes the stage-plate move vertically in a fixed line, without which the finder could not be used.

Fig. 148.




The use of the finder is so obvious, I think, as to need scarcely any description. The object (say a slide of diatoms) is placed on the stage and moved about until any particular form is in the centre of the field; and the figures (say 11–7) are at once apparent and ready for record. By reading the intermediate spaces as 11·5–7·5, or nearer, great accuracy may be obtained; divisions of $\frac{1}{50}$ of an inch on the arc will represent $\frac{1}{100}$ or the $\frac{1}{150}$ on the slide according to the distance from the centre E. Objects under powers of 1000 or 2000 diameters may be centered with the utmost accuracy, and the exact stiffness in motion can at all times be given by the adjustment of the screw centre E.

In one of the German forms a racked arc worked by a milled head is used, when of course very great accuracy may be obtained; but for ordinary purposes I think this simple plate will be found to answer most required purposes, and it could be easily fitted to almost any form of Microscope. I do not make any comparison of this method of object-finding with any of the other ingenious appliances in use, but I think it will be found useful and perhaps applicable in some cases where other methods might not be so convenient. Except in the case of putting on a large trough, there is no need even to remove it, as it makes an agreeable working stage."

**Wenham's Disk Illuminator.**—Fig. 149 (natural size) shows a plan of mounting this disk,* devised by Mr. Wenham specially for Ross's improved Microscope. The disk is held between two small vertical plates attached to the cap of a cylinder that rotates by screwing into a metal ring fitting beneath the object-stage; it is thus entirely free of the substage and mirror, and when adjusted, forms part of the object-stage. The power of rotation (a most important element to develope the best effects with the device) is provided by the screw fitting, which also serves to adjust the disk at the required level for immersion contact with the base of the slide. The rotating-plate is suitably cut to allow a large angle of obliquity to the incident rays.

* See this Journal, iii. (1880) pp. 145–7.

Mr. T. Curties also devised a method of mounting the disk for use in the ordinary substage (Fig. 150—½ scale). A rod is made to slide in a small spring-tube in a substage fitting; and the disk is fixed to a short pin attached to an angle-piece at the top of the rod for convenience of centering, &c.

FIG. 149.

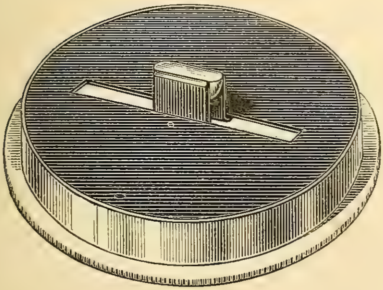
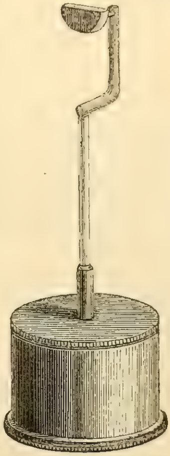


FIG. 150.



At a meeting of the Liverpool Microscopical Society last year, a very simple plan of mounting the disk was exhibited. A section of cork, about half an inch in thickness, was fitted to the stage opening beneath; and an aperture was cut in the cork suitably to hold the disk at the proper level and to allow free incidence of light.

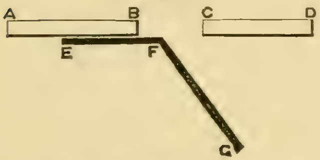
**Smith's "V-shaped Diaphragm."**—This was suggested by Dr. J. Edwards Smith in 1875 as of singular advantage in resolving severe tests, and he now says * that although in the interim a large variety of substage illuminators have been brought out, he still prefers it for "a *clean square* resolution of severe tests by oblique light." It consists simply of a piece of japanned iron plate (the ordinary "ferrotype" plate used by photographers) of say 3 inches square, which is fastened to the under side of the stage by one or more screws near its edge farthest from the mirror or lamp, and then bent down as shown in Fig. 151, the open side being adjacent to the source of illumination.

Dr. J. E. Blackham also records † his experience of the diaphragm for high angles, first pointing out that the name, V-shaped, is not well chosen, as the diaphragm itself is not V-shaped, but only forms one side of the V, the under side of the stage forming the other. "Of course, if the ferrotype plate is flat, it simply closes the well-

* Amer. Journ. Micr., vi. (1881) p. 59.
† Ibid., pp. 9–10 (3 figs.).

hole in the stage (and may thus be used for viewing opaque objects), but if one side of the plate is bent down, it leaves a wedge-shaped space between the plate and the under side of the stage, the apex of the wedge being toward the centre, and the base toward the outer edge of the stage. If the mirror be placed on the same side as the base of this wedge-shaped space, a beam of light can, upon swinging it out to a proper obliquity, be sent in upon the object, and no light less oblique can reach the object from below. As the ferrotype plate is perfectly pliable, it can be bent to any desired angle, and thus light of any desired degree of obliquity that the stage will admit can be obtained, quite free from any light of less obliquity.

Fig. 151.




A B C D is a section of the stage, E F G is the bent ferrotype plate forming the so-called V-diaphragm.

"With wide-angled lenses this has a remarkable effect in increasing the sharpness of resolution of fine-lined objects.

"With dry lenses of lesser angles the arrangement can be utilized to produce very fine dark-field effects, the diaphragm, in this case, being bent down *nearly* to the limit of the semi-aperture of the lens in use."

Dr. Blackham, in a previous article,* stated that with this single apparatus and a Tolles $\frac{1}{6}$ of 1·12 N. A. (= 95° balsam angle) he had frequently gone through the Möller balsam-mounted Probe-platte, resolving every diatom on it, using light from a common kerosene hand-lamp and concave mirror.

**Value of Swinging Substages.**—Considerable difference of opinion exists on this point, and the following is a statement of both sides of the question. The first seven paragraphs have been standing in type for some time, waiting for an opportunity for discussing the matter at one of the meetings of the Society.†

Mr. Grubb, in introducing his form of swinging substage to the Royal Irish Academy in 1853,‡ very clearly foresaw the advantage it would produce for oblique illumination. He dwelt particularly on "the power of directing the illuminating beam on the object at all angles of incidence . . . , and of registering the position at which peculiar effects are obtained." With Mr. Grubb's Microscope, however, the varying effects of obliquity of the illumination were obtained only by continued readjustment of the reflecting prism; the observer could not conveniently watch the effect of the changes in obliquity whilst actually making them—as with the Thury-Nachet traversing substage,§ which we regard as a very perfect realization of the advantages to be obtained by gradations of oblique illumination. The principle in this latter is indeed so good, that we hope to see it

* Amer. Journ. Micr., v. (1880) p. 44. † See *infra*, p. 713.
‡ Proc. R. Irish Acad., v. (1853) pp. 296–7. See this Journal, iii. (1880) p. 1056.
§ See this Journal, iii. (1880) p. 1060.

applied on a larger sector-carriage, so that greater range of motion may be allowed for the condenser. For use with our most recent homogeneous-immersion objectives, the motion in arc of M. Nachet's condenser is too limited to develope the fullest power of their apertures. The only reason we can assign for the neglect with which Mr. Grubb's sector and M. Nachet's traversing substage were received by microscopists in general, is that in those early days so few objectives were produced with apertures large enough to be used effectively in conjunction with such apparatus.

The intention of all the swinging arrangements—both those above referred to and the others described at pp. 1060–80 of vol. iii. —is to provide oblique illumination up to the highest limit of transmitting power of aperture possessed by our objectives; also to provide "dark-field" illumination beyond this limit, or opaque illumination above the horizon of the object under examination—together with exact means of registering the inclination of the light, &c., so that the effects may be repeated again with certainty.

It has, however, been objected to the swinging substage that it is an unnecessary incumbrance, as there are various condensers which convert axial into obliquely incident light up to the utmost practical limits of obliquity. Of those recently constructed with special reference to "immersion" illumination, we may note the Abbe-Zeiss oil-immersion condenser, Powell and Lealand's two forms,* and Stephenson's catoptric immersion illuminator.† In all these devices diaphragms are arranged to exclude a portion of the centre of the pencil, and to allow more or less of the peripheral zone to be utilized, the range of action being still further increased by the eccentric and rotating motions of the substage in which they are used.

There can be no doubt that to a very large extent these condensers give effects of oblique illumination equal to those obtained with the swinging substage; but it must be remembered that the latter enables us to regulate the precise *angle and amount* of light that is most effectual with every variety of objects. No disposition of diaphragms has yet been applied to condensers used in the axial substage to enable us to regulate the *amount* of light without altering the *obliquity*. In this respect, therefore, we think the swinging substage is an advantageous addition to the Microscope. A further advantage is the facility with which, by its means, the *mirror* or a low-power condenser may be used above the stage for the illumination of opaque objects.

Many experiments conducted with a view to the determination of the most efficient means for obtaining oblique illumination have led us to value the plan suggested by Mr. Bulloch, of Chicago, U.S.A., as shown in Fig. 141 on p. 1078, vol. iii. (1880). Placing the microscope horizontally, with the lamp attached to the concentric swinging substage, a hemispherical lens in immersion contact with the base of

* See this Journal, iii. (1880) p. 147, and p. 330, where one is figured.
† Ibid., ii. (1879) p. 36.

the fluid-mounted slide, and using as a substage condenser a 2-inch objective with the lower half of the front lens covered up, we have been able to obtain with a minimum expenditure of time some of the most satisfactory images by oblique light that we have yet seen.

It may not be superfluous to remark that the most modern developments of high-power microscopy tend more and more to the prolonged and exhaustive examination and study of individual specimens under every variety of effects of light. Here again it must be acknowledged that the swinging substage proves of service by the rapidity with which the changes of illumination can be effected, and the certainty with which they can be recorded and repeated.

We do not here attempt to decide which special system of construction is most effectual. The question whether the radial arc originally devised by Grubb embodies the principle in the most practical form, is open to discussion,—and this applies equally to the Thury-Nachet device, the Zentmayer's swinging arm, or Tolles's traverse-lens.

Some discussion took place at the June meeting of the Society upon the preceding note, in which Mr. Crouch, Mr. Stephenson, and others took part.

Mr. Crouch said that in the early part of the year 1876 the swinging substage was re-introduced by an American firm of opticians, and exhibited at the Centennial Exhibition held in Philadelphia in that year as an improvement upon the various forms then in use. "As it was almost immediately adopted in this country, and has since, with some slight modifications, been applied by various makers, both here and in America, it has occurred to me that the time has arrived at which it is possible to ascertain what the advantages offered are (if any), and whether they are of sufficient importance to necessitate the remodelling of those stands usually fitted with the substage. At any rate, I think the discussion of this subject can only tend to the elucidation of facts which are of importance in the construction of the modern microscope-stand.

"The substage, it need scarcely be stated, is an addition made to the Microscope for the more ready application of the illuminating accessories applied beneath the object, practically comprising the polariscope, various dark-ground illuminators, and the achromatic and other condensers, either dry or on the immersion system. For the two first-named methods it is not suggested that a swinging substage is of any advantage. For immersion condensers, also, it cannot be of use, and its application is therefore limited to dry condensers of presumably small angle and comparatively long focus. Now, as the result of my own experience, and also that of all those whom I have had the privilege of consulting, this is found to be the most unsatisfactory and uncertain of all methods of obtaining an oblique illuminating pencil.

"It will at once be conceded that the proportion of objects for which this method of illumination is useful is exceedingly small, consisting mainly of a few of the diatomaceous tests, the resolution of the striation of which requires objectives of great aperture and high power. The immense majority of objects, however, shown by transmitted light

require the use of objectives of lower aperture and power, ready means of applying the various accessories, and a firm stage with or without mechanical adjustments, giving a considerable range of motion.

"Now, since the introduction of the swinging substage, what do we find to be the tendency of the alterations either made or suggested? In the case of Microscopes provided with mechanical adjustments to the stage, a perilous attempt to reduce the thickness of the necessary plates and a serious limiting of the traversing movements with an increased complication of parts, which I can only look upon as a step backwards. For many years past the alterations made in the stand have all tended to a simplifying of construction and a consequent increase of strength, with less chance of derangement of the adjustments, and I cannot help thinking that we ought to be chary of making an addition which leads in the opposite direction, and which, as experience shows, only gives a result which can be better and more readily obtained by other means.

"I have only to add that I, with many others, shall be pleased to learn authoritatively whether anything has been done with the aid of this addition that has not been better done without it. I have the pleasure of the acquaintance of many possessors of Microscopes fitted with this adjunct, and as yet, with one exception, my inquiries have met with an answer unfavourable to it, the latest reply being that the owner had found it so inconvenient that he had made a fixture of it."

Mr. Stephenson said he concurred generally in the views expressed by Mr. Crouch.

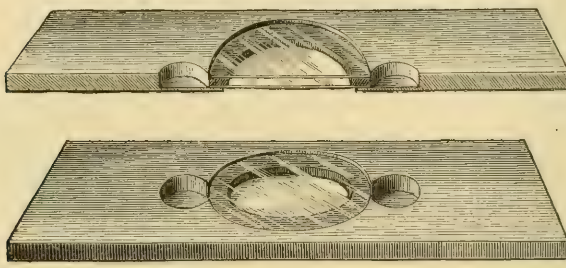
It must always be borne in mind—and this was a matter of fact and not a matter of opinion—that objectives having apertures exceeding the equivalent of 180° in air could only be fully utilized by some immersion appliance (condenser or otherwise), and it was essential that this should give an aperture at least as great as that of the objective employed. A lens, or prism, must in every such case be attached to the slide by some immersion fluid of a refractive index equal to or exceeding the numerical aperture of the objective. Of course the swinging substage might support an independent condensing lens throwing light on the lens or prism attached to the slide, making an arrangement similar to the traverse lens of Tolles, which was much simpler; but, as the full aperture of every objective could be utilized without a swinging substage, he preferred the ordinary rigid form which was better adapted for axial illumination.

**Botterill Life-slide.**—The description of this slide (Fig. 152) should have accompanied that of the "Botterill Trough," given at p. 148 of the previous volume.

It consists of a brass slide 3 in. × 1 in., having a central opening of $\frac{3}{4}$ inch with a flange, upon which a circle of cover-glass is cemented, forming the bottom of a cell. A narrow ring of vulcanite, &c., shown in the figure, fits in the opening to provide (when required) depth for the object to be examined, and another cover-glass is put over this. Two small countersunk wells on either side communicate with the central

cell, and enable the observer to remove or replenish the fluid. The advantages claimed for it are the facility with which it can be used and cleaned; its reversibility, allowing either side of the object to be examined through thin glass; the provision for renewing the supply of

Fig. 152.



water without disturbing any part of the apparatus, thus enabling objects to be kept under examination for an indefinite period; the same arrangement also allowing of the introduction of colouring matters, as carmine, indigo, &c.; and, lastly, its moderate cost and durability.

For Confervæ, small Infusoria, &c., it is sufficient to place the object on the bottom glass, with a drop of water, and apply the cover-glass in same manner as when using a glass stage-plate. When a thicker layer of water is required, the ring of vulcanite, cork, or other suitable material, of the requisite thickness, should be placed on the lower glass, and the object put in position, and the cover-glass applied as in mounting objects in liquid in a cell. The supply of water can be maintained by placing a drop occasionally in one of the side "wells," keeping the slide, when not under examination, in a small damp chamber, to prevent evaporation. To change the water, supply through one "well" and draw out through the other by means of blotting-paper.

**Botterill's Life-trough.**—Mr. Botterill objects* to the mode in which these troughs † are now made with *thick* glass. By using *thin* glass for both back and front a half-inch objective will focus up to the back of the trough, and higher powers, say up to the sixteenth immersion, can be used to examine objects on or near the front glass. Thin glass also allows a much better dark ground to be obtained with paraboloid or achromatic condenser.

With regard to the use of vulcanite, of which the troughs have been largely made,‡ Mr. Botterill prefers brass for general use and where marine organisms are not under examination, as brass allows thinner plates to be used and a flatter bevel consequently to be

* Sci.-Gossip, 1881, p. 160.
† For a description and figure, see this Journal, iii. (1880) p. 148.
‡ See this Journal, iii. (1880) p. 1082.

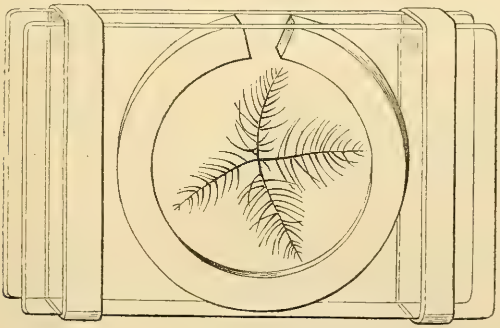
obtained, which is an advantage when higher powers than the one-inch are employed.

For keeping the glass apart, the " extra thick " indiarubber bands are the most generally useful, and in putting the trough together care must be taken to have the indiarubber and glass perfectly dry, as otherwise there is danger of a capillary leak.

**Hardy's Vivarium.***—Mr. J. D. Hardy suggests a trough (or vivarium as he prefers to call it) which obviates the main objections to the old troughs, viz.:—(1) Their superfluous depth; (2) The necessity for taking out the object and bottling it if desired to carry it anywhere for exhibition; (3) The water in the trough (through its being open at the top) is always more or less susceptible to every movement, causing some objects to have a constantly oscillating motion; (4) Their non-reversibility; and (5) The necessity for keeping them upright.

The apparatus (Fig. 153) consists of two pieces of glass 3 in. × 2 in. or 2 inches square, to the lower of which is cemented an india-

FIG. 153.



rubber or glass ring of any desired thickness, and this is covered on the upper side with some adhesive substance or simply greased to render it impervious. A funnel-shaped piece about $\frac{1}{4}$ inch wide is cut out of the ring at the top and the upper plate put on the ring, and the whole held together by strong indiarubber rings or springs.

The object having been placed on the lower plate, the upper one is put on, and the cell filled up with water through the hole at the top. The apparatus is reversible, and it can be plunged into a beaker of water in any position without fear of losing the object.

In view of the difficulty of using thin glass for high powers which would not bear the pressure required to keep the cell water-tight, Mr. Ingpen suggests † the use of two semicircular clips so as to be exactly over the indiarubber ring.

**Simple Growing-slide.‡**—Mr. T. Charters White suggests a form of growing-slide which contains its own fluid, and may be left under

* Journ. Quek. Micr. Club, vi. (1881) pp. 212–3 (1 fig.).
† Ibid., pp. 224–5. ‡ Ibid., pp. 201–2.

the Microscope for an indefinite period and notes made of every change occurring from day to day.

A cell is built up to a suitable and convenient size of the strips of thick plate glass, to be got from any glass merchant, then cement a piece of the same plate glass in the centre of the cell with Canada balsam and we have a water-tight cell with a table of plate glass in the centre, the space round which can be half filled up with water. The object being placed on this table in water and covered with thin glass, the water in the trough will keep up any loss by evaporation without any saturation of the table. It must necessarily be used with the Microscope in a vertical position.

**Wight's Growing-slide.*** — Mr. W. H. Wight, of Baltimore, finding the supply of water in the older forms of growing-slide to be too limited and too soon exhausted, describes and recommends the following :—

A small hole is drilled near the margin of a concave slide, or near the centre of a plane one. Through this hole put a strand of cotton thread with one end in contact with the glass cover, the other immersed in a vessel containing the water, such as a soap dish, on which the slides can be rested. Thus there is perfect circulation and a large supply of water. The advantages of the plan are that it is inexpensive and the glass slip can readily be used as an ordinary slide, besides the opportunity always afforded of finding anything on the slide worth future study, and of immediately converting it into a growing-slide, thus avoiding the loss of rare objects.

In a convenient *résumé* of the growing-cells hitherto devised,† Dr. A. C. Stokes, having had Mr. Wight's slide in constant use for a month, finds it worthy of every consideration. A hole not more than $\frac{1}{32}$ inch in diameter, drilled by the sharpened shank of an old cataract-needle and a piece of Clark's No. 70 sewing cotton doubled and loosely twisted, have kept a deep cell abundantly supplied with water for many days, a channel being cut in the ring for the thread and another opposite to facilitate evaporation.

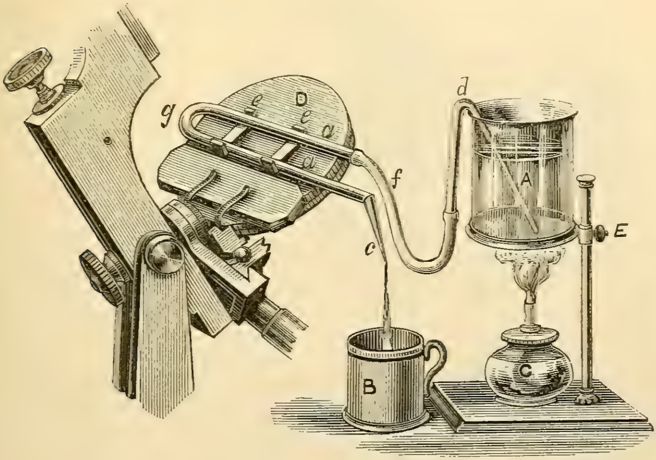
**Bartley's Warm-stage.‡**—Professor E. H. Bartley uses the apparatus illustrated in the accompanying sketch, which is claimed to be easy of construction, and to answer the purpose well.

It consists of a vessel of water A, which is supported on a tripod or a lamp-stand, and capable of being raised and lowered at will ; the water in it is kept boiling when in use by the lamp C. A glass tube *a a*, about 6 mm. in diameter, and about 30 cm. long, is bent upon itself at *g*, so as to bring the two limbs parallel and within about 1·5 cm. of one another. One of the ends of this tube is then drawn off to a fine point, as shown at *c*, and is bent at an angle of 45° at a distance of 3 cm. from this end. The other limb of this tube is connected with the siphon tube *d*, by the rubber tube *f*. D is the stage of the Microscope, and *e e* are two pieces of cork which serve as

* Amer. Mon. Micr. Journ., ii. (1881) p. 23.
† Amer. Journ. Micr., vi. (1881) pp. 50–8 (18 figs.).
‡ Amer. Mon. Micr. Journ., i. (1880) pp. 181–2.

supports for the tube *a a* and as stops for the slide, and which may be cemented to the stage by mucilage, to make the apparatus more steady. These corks can be replaced by strips of sheet tin or brass, so bent as to serve the same purpose. The tube *a a* is placed in the usual position of the slide upon the stage, and the slide is placed

Fig. 154.




upon it; the light passes between the two limbs of the tube. The vessel B receives the water discharged at *c*. As long as the water in A is kept at 100° C., and a constant relation is maintained between the height of the water in this vessel and the stage, the temperature of the slide will remain constant as long as the water flows. By raising or lowering A, the velocity of the current of water may be increased or diminished, and the temperature of the slide is controlled.

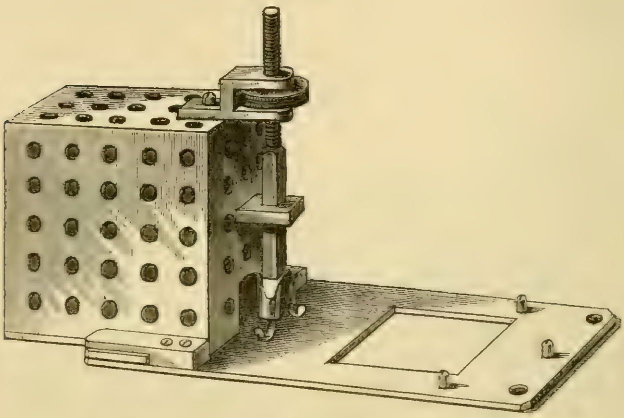
By a somewhat rough measurement of the temperature obtained with this apparatus, Professor Bartley finds it possible to procure a range of about 45° C., or from 27° C. to 70° C. As the normal temperature of the human body is 37° C., it will be seen that the range is all that is needed for the object for which it was intended. The higher temperatures are convenient for favouring chemical reactions under the Microscope, or for the evaporation of liquids, or other uses where a gentle heat and uniform temperature are desired.

**Hume's Frog-plate.**—Mr. A. Hume has devised the apparatus shown in Fig. 155,* for the greater convenience of the frog while under examination. To a plate of the ordinary form is attached (sliding in grooves) a brass box without a bottom, and pierced with apertures, in which the frog is placed, and in which it can freely

* See this Journal, iii. (1880) p. 174.

breathe. A clip shown at the end of the box can be screwed down by the milled head, more or less, so as to confine the frog's leg (which is

Fig. 155.



brought through the large hole shown in the box), the web of the foot being placed over the aperture of the plate, and examined in the usual way.

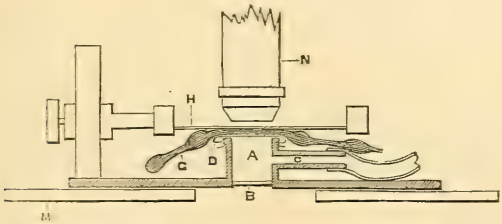
**Apparatus for Investigating Capillary Blood-pressure (in the Frog's Foot).***—Drs. C. S. Roy and J. Graham-Brown describe the apparatus they employed in their investigations on this subject. Their observations were confined to tissues, the capillary circulation of which could be watched through the Microscope, the web of the frog being preferred, since it permits a study of the phenomena of the blood-flow through the minute vessels without interfering to any important extent with either the general or local circulation. To control the data obtained, however, most of the experiments were repeated on the tongue and mesentery of the frog, and on the tails of newts and small fishes. The principal facts learned were of such a nature as to leave little doubt of their general applicability to the peripheral circulation of warm-blooded animals.

In Fig. 156 is represented (somewhat diagrammatically) one of the arrangements which was finally found the most convenient. In the centre of a brass plate, measuring 10 cm. by 4·5 cm., is screwed the cylinder A (2·8 mm. internal diameter, and its upper edge 6 mm. above the plate), closed below by the glass plate B, the junction being air-tight. The upper outlet of the cylinder is closed by the delicate transparent membrane D, which presses upon the web, tongue, or other part examined, when the pressure of the air within the cylinder is raised. Counter-pressure is exerted by the thin glass plate H, which is so arranged that it can be fixed at any desired height above

* Journ. Physiol. (Foster), ii. (1880) pp. 325–30.

the cylinder. The part to be examined is placed between the cylinder and the glass plate, which is lowered as far as is possible without causing compression of the tissue between it and the edge of the cylinder; G represents the web seen in section, M is the stage of the Microscope, and N the objective.

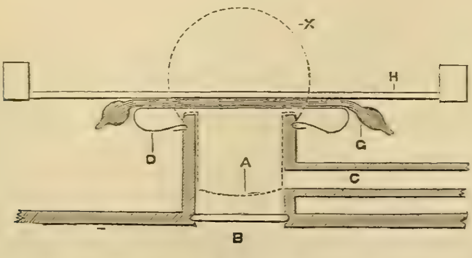
FIG. 156.




The membrane D must be sufficiently transparent to allow of the capillary circulation being seen clearly, even with high-power objectives. It must be flexible enough to transmit equally to the tissue examined the pressure of the air within the cylinder, and it must be as inelastic as possible, or, at all events, its elasticity coefficient (to use a convenient but scarcely accurate term) must be considerably greater than that of the tissue against which it presses, so that the latter may not be stretched to any important extent when the pressure in the cylinder is raised. The manner in which it is fastened on the cylinder must also be such that the pressure acting on that part of the web, &c., which lies within the field of the Microscope, i. e. the part lying in the centre of the area of contact between the web and membrane, will, when the instrument is arranged as in Fig. 156, be exactly equal to the pressure of the air within the chamber or cylinder A.

The first three of these conditions are fulfilled to perfection by the membrane which the author used from the peritoneum of the calf, and used by druggists for fastening the stoppers of perfume bottles (not to be confounded with the much thicker membrane also used for the same purpose).

FIG. 157.

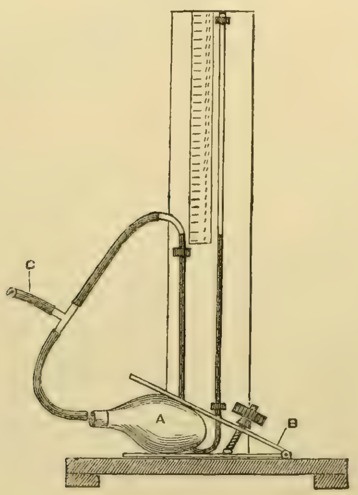



The manner in which the membrane must be fastened on the cylinder A, is illustrated by Fig. 157. A piece of the membrane having

been moistened with water, is placed over the cylinder A, into which it is then pushed with the rounded end of a glass rod, so that it takes up the position represented in section by the dotted line. It is then securely tied by a thread resting in the groove cut for the purpose at the upper edge of the cylinder. On now raising the pressure within the chamber, by introducing air through the tube C, the membrane bulges out in the manner indicated by the line $x$. When, however, it is prevented from taking this position by the pressure of the glass plate H, or rather by the web, or other part, which is placed below the latter, it applies itself to this tissue, in the way represented by the line D.

The pressure of the air within the cylinder—that pressure to which the tissue lying within the field of the Microscope is subjected—is regulated by an arrangement which is illustrated by Fig. 158. The

Fig. 158.

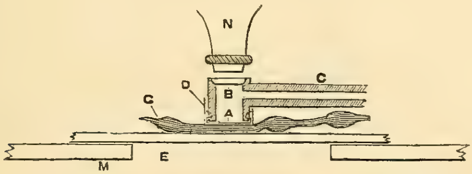



caoutchouc bag A containing air, can be compressed between the brass plates B, hinged together at one end, and which can be approximated by means of a screw. A T-tube connects the caoutchouc bag on the one hand with a water manometer, and on the other (C) with the cylinder A (in Figs. 156 and 157). In this way the pressure within the chamber can be regulated with the greatest nicety.

In the case of the web, care was at first taken that no part of any of the toes was included within the area to be compressed. It was afterwards found, however, that this precaution was unnecessary, the result of raising the pressure applied being the same so long as the part lying in the field was not too near one of the toes.

The modification illustrated by Fig. 159 was employed to prove that the pressure applied to the tissue in the centre of the compressed area is really that which is signified by the manometer. The little round chamber A, closed above by the glass plate B, and on the under end of which a membrane is fastened, is held by an appropriate holder immediately above the web, but not in contact with it. The

FIG. 159.




ordinary glass slide E, upon which the web G rests, serves to exert a counter-pressure. In order to prevent the membrane bulging out laterally, there is placed round the lower part of the cylinder, but not connected with it, a light ring of waxed paper, seen in section at D. The paper ring rests upon the web, and is so light that its presence has no appreciable influence on the circulation of the part.

In so far as the pressure is concerned, the authors have, with this arrangement, included a portion of web within a rigid box, closed below by the glass slide lying on the microscope-stage, above by the little glass plate B, and limited laterally by the cylinder and the ring of waxed paper, and the membrane. There is, at the same time, no interference with the entrance and exit of blood to and from the part of the web to be examined, other than that intentionally produced by raising the pressure within the chamber.

They made a number of careful experiments with this little apparatus, comparing the results obtained by its help, with those given by the simpler arrangement illustrated by Fig. 156, and are thoroughly convinced that, for any individual case, *cæteris paribus*, the arterioles and capillaries of a given part are made to collapse at the same pressure with both methods. It is not pretended, of course, that, with the arrangement represented in Fig. 156, the pressure on the web is equal over the whole area of contact between it and the membrane. Doubtless, at the edge of this area, the pressure applied will be somewhat less than it is at the centre. It is only the central part, however, which can come within the field, and for this part, as already mentioned, the pressure which acts upon the tissue is correctly indicated by the manometer.

The frogs used (*R. esc.* as well as *R. temp.*, and the greater number winter frogs) were for the most part uncurarized, as the blood-pressure of curarized animals is liable to variations which do not occur in the case of uncurarized animals. It was found that it is very easy so to fasten a frog upon an appropriate holder, that, while the

foot and body are kept fixed, the general circulation is little or not at all interfered with. The animal may be kept under observation with the Microscope for many hours, without the slightest fall in the blood-pressure resulting.

As the greatest care in attending to details is necessary in investigations such as those in question here, the manner employed for fastening the frogs for examination may be explained. Through the narrow slip of wood upon which the animal rests are cut, near one of its ends, two large holes to allow the passage of the piece of tape which is used to fix the four limbs. The circulation through these is necessarily interfered with to some extent by their being so held, but this it is scarcely possible to avoid without curarizing the animal, and thereby introducing a more serious cause of error. One web having been spread out and fixed by threads to the forked extremity of the holder, the other leg is bent upon itself, as when it is drawn up voluntarily by the animal, in which position it is held by a tape passing loosely round it. It is not difficult so to arrange the tape that it will only press upon the leg when extension is attempted. The leg corresponding to the web which is to be examined is prevented from being drawn up by means of pins stuck into the wood on each side of it. These are placed so that, while they effectually prevent the least flexion, they do not press upon the limb when the latter is at rest. Usually one was placed on the inner side of the ankle, a second on the outer aspect of the knee, and a third on the opposite side of the body close to the pelvis. These are stuck somewhat obliquely into the wood, so that they overhang the part next them, and prevent the leg being raised from the board. In these circumstances frogs will often remain quite motionless for many hours, in a condition more or less closely resembling the so-called "magnetized" state, which can be so readily induced in birds and some other animals.

When the tongue or mesentery was examined the frogs were curarized. For studying the pressure in the vessels of the tail of the fish, a small trough, similar in principle to that recommended by Caton, was used, and in this case an arrangement such as that illustrated by Fig. 159, but without the paper ring, was employed.

**Rogers' Micrometers.**—Prof. W. A. Rogers, of Cambridge, U.S.A. (a Fellow of this Society), having completed his dividing engine, which has been three years in construction, at a cost of $4000, is willing to furnish standard micrometers without cost to any competent person who will make a careful study of the subdivisions, and who will at the same time agree to publish the results, without communication with him; and in order to meet a small portion of the expense incurred in the construction of the machine, he is also prepared to make standards, guaranteed to be aliquot parts, either of the British imperial yard "Bronze 1," or of the "Mètre des Archives."

At present Prof. Rogers will make the following patterns:—

1. 101 lines ·001 inch, and 101 lines ·001 cm. with the first line in each common to both.
2. 301 lines, 100 coarse, 100 very fine, for high powers, 101 coarse, all ·01 mm.

3. 501 lines ·01 mm., and 501 lines $\frac{1}{2500}$ inch.
4. 1001 lines ·01 mm., and 1001 lines $\frac{1}{2500}$ inch.
5. The same as the preceding one, but with both sets of lines double; that is, ruled both with fine and with coarse lines. In all the above, the 5th and 10th lines are longer than the others.

The object in ruling the lines $\frac{1}{2500}$ of an inch apart is to permit of ready comparison with the ·001 mm. lines, these spaces being approximately equal. It will be seen that one band acts as a vernier to the other.

The extreme working length of the screw of the machine is half a metre. The theoretical limit of subdivision is about two billionths of a centimetre. The practical limit may be set at about one fifty-thousandth of a centimetre.

**Ideal Series of Objectives for Microscopical Work.***—Governor S. D. Cox, of Cincinnati, suggests the following as what might fairly be called an ideal series of lenses:—

"(1) An objective of 40° aperture and half an inch working distance, giving about 40 diameters magnification with the ordinary No. 1 ocular, and resolving 38,000 lines to the inch. (2) An objective of 100° aperture and one-eighth of an inch working distance, giving about 120 diameters, and resolving 70,000 lines to the inch. (3) A homogeneous-immersion objective of 120° balsam-angle of aperture, giving about 300 diameters, and resolving 120,000 lines to the inch. Proper eye-pieces would make these three objectives cover the intermediate magnifications desirable, and the third objective in the list would resolve any test resolved by any glass yet made and in the market, whilst the 40° glass would give all the 'penetration' needed for the binocular with opaque objects."

Dr. J. Edwards Smith also recommends † the following series of objectives as best fitted for microscopical work chosen from the standpoint of a protracted experience "over the tube":—

First, a $\frac{2}{3}$-inch, aperture 45° to 47°, having a working distance of $\frac{1}{4}$ inch, thus suitable for wet mounts without covers, and resolving 35,000 to 40,000 lines. This comes tolerably close to the ideal inch of 40°, both as to resolving power and working distance.

Second, a "real good honest" $\frac{1}{2}$ inch of 40°, recommended as a "hack" and for work over acids, &c.

Third, a first-class wide-angled duplex objective, say a $\frac{1}{6}$ or a $\frac{1}{10}$, resolving all the most difficult tests.

**High Amplifications.** ‡—Referring to the note at pp. 127–9 of this volume, Dr. Phin disclaims the idea of being an advocate for excessive amplifications; on the contrary, he has always opposed their use. "It "is now pretty well recognized that very high-power objectives do not "reveal anything more than those of moderate power, it being assumed

* 'Cincinnati Medical News,' Jan. 1881.
† Amer. Journ. Micr., vi. (1881) pp. 66–7.
‡ Ibid., p. 64.

"that the latter are of first-rate quality and used with high eye-pieces, "and the question comes up, 'How high may the eye-piece be?' Our "own impression is, that the same circumstances which prevent the "successful construction of high objectives will prevent the construc-"tion and employment of high eye-pieces. Just where the limit lies "it may be difficult to state, but we doubt the efficacy of any eye-piece "higher than a one-eight. This, with an objective of one-tenth would "give 8000 to 10,000 diameters, and this seems to be about the limit "arrived at by our best workers."

**Conditions of Microstereoscopic Vision—"Penetration."**—It is well known that, although binocular Microscopes have been devised which allow the use of high powers, there is always a very marked falling off in the *stereoscopic* effect. Several unsuccessful attempts have hitherto been made to elucidate this on theoretical grounds. Professor Abbe has, however, now published * an elaborate discussion of the conditions of microstereoscopic vision which clears away the difficulties which have attended the previous considerations of the subject.

In an introductory part he points out that the stereoscopic effect of binocular observation in the Microscope is fettered by restrictions which are not in any way caused by the action of the particular stereoscopic apparatus, but arise from the general laws of microscopic vision. The *direct* appreciation of solid forms in binocular vision obviously cannot extend further than the delineation of them goes. It is only when an object can be *seen* in all its parts in *one* field of the Microscope (that is, under one focussing) that a true stereoscopic image of it is obtained. So long as only a small part of the object is visible *simultaneously* with any distinctness, no stereoscopic apparatus, however perfect, can bring into view the form of the whole. Now as the amplification is increased the Microscope continually loses in *depth*, and this decrease in depth (starting with the lowest powers) is not simply proportional to the amplification, but is in a very much greater ratio. Thus with an amplification of 300, the depth is not the $\frac{1}{10}$th of that with 30 times, but about the $\frac{1}{50}$th only, so that an entirely *disproportional* loss of depth takes place, and it is only when we pass beyond the medium powers that the further decrease becomes approximately proportional to the amplification. But already with an amplification of not more than 300 times the absolute depth of the image scarcely amounts to the hundredth of a millimetre, and with 1000 times not even to a micromillimetre. The thickness of the object which can be seen in *one* field of the Microscope therefore decreases more and more with increase of amplification, at first (commencing from the lowest powers) very rapidly, and not in a less degree until the depth of vision has become very small. The scope for stereoscopic observation must always be restricted in the same ratio. Only under relatively low amplifications is a direct solid view of those objects possible whose depth is a considerable fraction

* Zeitschr. f. Mikr., ii. (1880) p. 207.

of the diameter of the field. Even with medium powers of 200–300 only very thin objects can be seen in relief, and with high powers we are confined to objects, the depth of which does not exceed a few micromillimetres.

It is seen, therefore, that fairly satisfactory stereoscopic observation cannot be extended in general beyond moderate amplifications, not even when the binocular apparatus allows the use of high powers. As soon as these become necessary stereoscopic perception is limited to objects of so little depth that a plastic view of them can hardly be productive of any scientific advantage, although effective images are still possible with *suitable* objects. It follows therefore, that in regard to the more difficult problems of microscopical observation, any substantial aid by means of binocular vision is necessarily precluded.

The following is a full translation of Professor Abbe's paper so far as it relates to the theoretical question, with, however, some modifications and additions by himself:—

The questions which relate to *depth*-perspective or visual *space* (as distinguished from *field*) in microscopical vision have never hitherto been elucidated, though their solution constitutes the data for a proper notion of the conditions of micro-*stereoscopic* vision.

The delineation of *solid* objects by a system of lenses is, by virtue of the most general laws of optical delineation, subject to a peculiar disproportion in amplification. The linear amplification of the *depth*-dimension (parallel to the axis of the optical system) is when object and image are in the same medium, always equal to the *square* of the linear amplification of the dimensions at right angles to the axis; and if the object is in a more highly refracting medium than air, it is equal to this square divided by the refractive index of the medium. In every case, therefore, it will be found that in proportion to the lateral amplification there is a progressive and with high powers a rapidly increasing *over-amplification* of the depth of the three-dimensional image. When, for example, a particular transverse section of the object is magnified 100 times in breadth, the distance between the planes of parts lying one behind the other is magnified 10,000 times, at the corresponding points on the axis, when the object is in air, 7500 times when it is in water, and still as much as 6600 times when it is in Canada balsam.

The excessive distortion above described with high amplifications would not, however, *of itself* so much hinder the correct appreciation of solid forms in the microscopical image as might appear at first sight. For by virtue of the geometrical character of optical image-formation, the solid image maintains a correct perspective in spite of the over-amplification of the one dimension, although this perspective with high amplifications becomes extremely abnormal—to some extent comparable to that which results in ordinary vision by a large object being placed close to the eye. Since, however, the appreciation of solid forms is in no case merely a matter of sensation, but always originates in an act of conception, the peculiarity in the optical image referred to would not prevent the solid object being correctly

seen under any amplification—at most it could only cause some difficulty by its uncouth perspective—so long as the visual impressions furnished sufficient salient points for the construction of the retinal image as a solid or three dimensional one. For this, however, to be possible it is plainly essential that the solid object should be *simultaneously visible* within a certain not too small depth; for obviously no indications could be derived of the constituents of space if the Microscope at each adjustment only allowed a single layer of inappreciable depth to be clearly recognized. All optical apparatus for obtaining such indications with binocular vision must remain ineffective if the images themselves give no clear impression of anything that relates to the third dimension.

The over-amplification of the dimension of depth inseparable from the action of optical instruments comes, it will be seen, to be an insuperable obstacle to efficient stereoscopic vision with high powers, because as the consequence of that want of proportion in the solid image—and for that reason only—the visual *space* of the Microscope loses more and more in depth as the amplification increases, and approaches more and more to a bare transverse section of the object.

This visual *space*, that is the solid space occupied by the object, which at *one* adjustment of the Microscope is plainly visible to the eye, is made up of two parts, the limits of which as regards the *depth* are determined in a very different manner.

First, the *accommodation* of the eye embraces a certain depth, different planes being successively depicted with perfect sharpness of image on the retina, whilst the eye—accommodating itself consciously or unconsciously—is adjusted by degrees to virtual images of greater and less distance of vision. This depth of accommodation, which of course in the perception of the relations of space plays precisely the same part in microscopical as in ordinary vision, is completely determined by the extent of accommodation of the particular eye, the limits being the greatest and shortest distance of distinct vision. Its exact numerical measure is the difference between the *reciprocal* values of these two extreme distances. If the capacity of accommodation of a particular eye is expressed thus numerically, the depth of accommodation for the same eye in microscopical vision for any given linear amplification may be exactly computed independently of the composition of the Microscope, provided the index of refraction is given of the medium in which the object under observation is placed. The depth of perfectly distinct vision is directly proportional to the above-mentioned numerical equivalent of the extent of accommodation of the eye, directly proportional to the refractive index of the medium of the object, and inversely proportional to the *square* of the amplification when referred always to the same image-distance (say 250 mm.). Assume, for example, that for a moderately short-sighted eye the nearest point of distinct vision is 150 mm., and the farthest point 300 mm.—in which case the numerical equivalent of the extent of accommodation would equal $\frac{1}{300}$ mm.—the calculation for an object in air would give a depth of vision by *accommodation* amounting to

| | | | | |
|---|---|---|---|---|
| 2·08 | mm. | with | 10 | times amplification. |
| 0·23 | ,, | ,, | 30 | ,, |
| 0·02 | ,, | ,, | 100 | ,, |
| 0·0023 | ,, | ,, | 300 | ,, |
| 0·00021 | ,, | ,, | 1000 | ,, |
| 0·00002 | ,, | ,, | 3000 | ,, |

all the amplifications being referred to the conventional distance of 250 mm.

These figures would be uniformly increased in the ratio of 3 : 4 or 2 : 3 if the object is supposed to be in water or in balsam. For a more short-sighted eye, but capable of great accommodation, the limits of vision being 200 and 100 mm., the above values for the depth would have to be increased in the ratio of 2 : 3; on the other hand, for a long sight in which distinct vision only reaches to 500 mm. as the nearest point, they must be decreased in the proportion of 5 to 3. The construction of the Microscope (apart from its total amplification) has nothing at all to do with these effects.

Secondly. The perception of depth is assisted by the insensibility of the eye to small defects in the union of the rays in the optic image, consequently small circles of confusion in the vertical image. As a result of this, in a fixed adjustment of the Microscope and a fixed condition of accommodation of the observer's eye, transverse sections of the object which are a little above and below the *exact* adjustment are nevertheless seen without sensible or at any rate prejudicial indistinctness. The total amount of depth so obtained is the so-called *depth of focus* of the Microscope. In order to determine it numerically, the allowable magnitude of the circles of confusion in the microscopical image must be defined by the visual angle under which they may appear to the eye. In accordance with experience, 1 minute of arc would denote the limit for very sharply defined vision, 2 to 3 minutes for vision still pretty distinct, and 5 to 6 minutes the limit for vision only just tolerable. If the amount of the allowable indistinctness is determined in this way, the focal depth depends further only upon the refractive index of the medium in which the object is, the amplification and the angle of aperture of the Microscope (or the angle of the admitted pencil if the whole aperture is not filled with rays), but is quite independent of all other circumstances. Its value may be computed for each particular case from a simple formula, according to which it is directly proportional to the refractive index of the object medium and inversely proportional to the "numerical aperture" of the objective, as also to the first power of the amplification. To take an example; assume the visual angle of allowable indistinctness to be fixed at 5′, and the aperture-angle of the image-forming pencils to be 60° in air (corresponding to a numerical aperture of 0·50), the depth of focus of an object in *air* will then equal

| | | | | |
|---|---|---|---|---|
| 0·073 | mm. | for | 10 | times amplification. |
| 0·024 | ,, | ,, | 30 | ,, |
| 0·0073 | ,, | ,, | 100 | ,, |
| 0·0024 | ,, | ,, | 300 | ,, |
| 0·00073 | ,, | ,, | 1000 | ,, |
| 0·00024 | ,, | ,, | 3000 | ,, |

where again the amplification is referred to the conventional image-distance of 250 mm.

By limiting more the amount of allowable indistinctness, all these figures would be correspondingly reduced, and by enlarging the limit they would be increased. On the other hand, they rise in proportion to the refractive index if the objects are in water, balsam, &c. In the same way they would be increased if aperture-angles of less numerical equivalent than 0·50 were made use of, as would always be the case with low powers, and with higher powers if the illumination was by narrow cones of rays, and the objects produced no perceptible dissipation of the incident rays.

It is obvious that the actual *depth of vision* must always be the exact sum of the *accommodation depth* and *focal depth.* The former denotes that object space which the eye, through the play of accommodation, is able to penetrate with perfect sharpness of image; the latter gives the amount by which this object space is extended in its limits—reckoning both from above and below—because without perfect sharpness of image there still remains a *sufficient* distinctness of vision.

The very unequal course of the two constituent parts of the visual depth appears directly from the two series of numbers given above, but will be still more evident if we compare the depth values of both series, calculated for the particular amplifications, with the *lateral* diameter of the field for the same amplifications. The latter—the linear *field of vision* of the Microscope—depends exclusively upon the amplification and upon the angle of field * of the eye-piece employed; and when the latter is taken as constant, is inversely proportional to the amplification, whatever the construction of the Microscope may be. If, for example, the diaphragm of the eye-piece appears under a visual angle of 53° (corresponding to the trigonometrical tangent 0·50 for the semi-angle), then the absolute diameter of the visible field will be

| | | | | |
|---|---|---|---|---|
| 25 | mm. | for | 10 | times amplification. |
| 8·3 | „ | „ | 30 | „ |
| 2·5 | „ | „ | 100 | „ |
| 0·83 | „ | „ | 300 | „ |
| 0·25 | „ | „ | 1000 | „ |
| 0·083 | „ | „ | 3000 | „ |

The *accommodation depth* (the same assumptions being made as in the above example) will not remain a constant fraction of the field of vision as would be the case if there were no over-amplification in depth,† but would amount to—

* The "angle of field" of an eye-piece is that angle under which the rays emerge which meet opposite points of the diaphragm. It is at the same time the visual angle under which the field is seen projected by the eye.

† If the amplification of the object were increased 10 times, the absolute diameter of the field would be reduced to $\frac{1}{10}$, and a similar reduction in the depth would leave the ratio of depth to field unchanged.

| | | | | |
|---|---|---|---|---|
| With | 10 | times amplification | $\frac{1}{12}$ | of the field of vision. |
| ,, | 30 | ,, | $\frac{1}{36}$ | ,, |
| ,, | 100 | ,, | $\frac{1}{120}$ | ,, |
| ,, | 300 | ,, | $\frac{1}{360}$ | ,, |
| ,, | 1000 | ,, | $\frac{1}{1200}$ | ,, |
| ,, | 3000 | ,, | $\frac{1}{3600}$ | ,, |

The over-amplification of the depth-dimension, inherent in the optical formation of the image, produces therefore, as the amplification increases, a more and more unfavourable relation between the depth and width of the object-space accessible to accommodation. Whilst with 10 times amplification the relation is about that of a pretty thick book, with 3000 times amplification it equals only a single leaf of the book.

The other constituent of the depth of vision, the *depth of focus*, on the other hand, shows an essentially different relation, because the effect of over-amplification is here directly compensated by the narrowing—proportionally to the amplification of the Microscope—of the pencils passing from the eye-piece to the eye. For the limits of perfectly distinct vision by varying accommodation, it is obviously a matter of indifference whether the pupil receives narrow or wide pencils. But the increase in the circles of confusion when the near or distant points of distinct vision are overstepped is proportional to the diameter of the image-forming pencil at its entrance into the eye. The result of this is, that in spite of the over-amplification of the depth-dimension, the solid space recognizable by virtue of the focal depth maintains a *constant* relation between breadth and thickness as long as the same angle of aperture and the same object medium are considered, and as long as a fixed limit is retained for the allowable circles of confusion.

For an effective aperture of 0·50, air as medium, and 5′ as the allowable visual angle of the circles of confusion, this constant relation of depth to the diameter of the field of view corresponding to the depth of focus is $\frac{1}{343}$, consequently a very small fraction, notwithstanding that a pretty wide latitude is here allowed for indistinctness.

The depth is increased to about $\frac{1}{200}$ when under the same assumptions in other respects the object is supposed to be in balsam, and it may be further raised in a considerable proportion when the much smaller angles of aperture are taken into account which are available with lower amplification or with illumination by narrow pencils. These examples show this much however, that when the amplification is low the focal depth in every case falls very much into the background as compared with the accommodation depth, which even for eyes with small capacity of accommodation must still retain a considerable magnitude, whilst inversely under very high amplifications the efficacy of accommodation falls more and more behind the small but constant effect of focal depth.

Combining the preceding figures we have the following table showing the total depth of vision from 10 to 3000 times.

| Amplification. | Diameter of Field. | Accommodation Depth. | Focal Depth. | Depth of Vision (Accommodation Depth + Focal Depth). | Ratio of Depth of Vision to Diameter of Field. |
|---|---|---|---|---|---|
| | mm. | mm. | mm. | mm. | |
| 10 | 25·0 | 2·08 | 0·073 | 2·153 | $\frac{1}{11\cdot6}$ |
| 30 | 8·3 | 0·23 | 0·024 | 0·254 | $\frac{1}{32\cdot7}$ |
| 100 | 2·5 | 0·02 | 0·0073 | 0·0273 | $\frac{1}{91\cdot6}$ |
| 300 | 0·83 | 0·0023 | 0·0024 | 0·0047 | $\frac{1}{176\cdot6}$ |
| 1000 | 0·25 | 0·00021 | 0·00073 | 0·00094 | $\frac{1}{266}$ |
| 3000 | 0·083 | 0·00002 | 0·00024 | 0·00026 | $\frac{1}{319}$ |

The result of this discussion shows that direct vision of solid objects in the Microscope depends, with small amplifications, to a preponderating extent on the capacity of accommodation of the eye. The efficacy of *this* factor in small amplifications renders possible to a considerable degree the appreciation of depth, which is the essential postulate of effective stereoscopic effect in binocular vision. That which is contributed by focal depth is under these circumstances inconsiderable. With medium amplifications from 100 up to 200, the effect of accommodation no longer exceeds so greatly the focal depth, and the total perspective of depth resulting from both factors is reduced to a somewhat small fraction of the diameter of the field of view. Its absolute amount still, however, reaches (even with such amplifications) to hundredths of a millimetre with objects that are in highly refracting media and with the use of small aperture-angles. With high amplifications the efficacy of accommodation ceases almost entirely, and the whole visual depth becomes more and more merely focal depth. If the amplification reaches or exceeds 1000, the absolute depth of the visual space is reduced to micromillimetres, and finally to a fraction of $\mu$. The microscopical images of solid objects pass, in this case, more and more into pure *transverse sections*.

The decrease of the visual space and corresponding thereto of the depth of all objects capable of being conceived as *plastic* in binocular vision, proceeds, with the smallest amplifications, approximately as the square of the amplification, and therefore at first very rapidly because with low powers the effect of accommodation is what affects it almost exclusively. With high amplifications, on the contrary, in which focal depth only and no accommodation depth of any consequence exists, the flattening of the visual space proceeds slower, and at last progresses as the first power only of the amplification.

The limited operation of stereoscopic apparatus for other than quite moderate amplifications is therefore apparent. At the same time we are able to gather some hints with respect to the conditions

which set limits to the depth-perspective in microscopic vision—on the influence of the medium in which the object is, on the influence of the aperture-angle of the objective, or of the incident illuminating pencils, and on the influence which the very unequal extent of accommodation of the eyes of different individuals must have on the capacity for stereoscopic vision especially with low powers—in particular it leads to a rule of *general* application which should always be applied where stereoscopic observation is concerned, which is—use always the *lowest* amplification sufficient for distinctly recognizing the object, and in observations with transmitted light employ as narrow a pencil as is compatible with sufficient illumination of the image.

In conclusion, we may refer to the general importance in microscopical investigations which this disproportion of amplification in the three-dimensional image of all optical instruments possesses. The foregoing considerations point to the over-amplification of depth-dimension as an obstacle for a more extended application of stereoscopic observation. It should, however, be pointed out that whilst this peculiarity hinders and limits the *direct* appreciation of solid forms, yet it to the same degree supports and extends the *indirect* recognition of space relations. When with increase of amplification the depth-perspective of the Microscope becomes more and more flattened, at the same time the images of different planes stand out from each other in an equal degree more perfectly, and are in the same degree clearer and more distinct. With an increase of amplification the Microscope acquires more and more the property of an *optical microtome*, which presents to the observer's eye sections of the object of a fineness and sharpness that no instrument could produce by mechanical means. The over-amplification of the depth is the foundation of this capacity in the Microscope, which enables the observer by successive adjustments for a series of consecutive planes to *construe* the solid forms of the smallest natural objects with the same certainty as he is accustomed to *see* with the naked eye the solid forms of macroscopic objects. It cannot be doubted that this positive gain from the peculiar action of optical systems is a far greater advantage in the general scientific use of the instrument than could ever be expected from an extended application of stereoscopic observation.

☞ Since the original publication of the above paper, Professor Abbe has sent us the following brief summary of the principal formulæ which are the basis of the preceding discussions.

(1) The *over-amplification of the depth* in the solid microscopical image results from a general proposition, which may be expressed in the following way. Let A and B denote two points on the axis of an optical system on the side of the object, and $\delta$ their distance; M the linear amplification of a plane object at A, N the linear amplification of a similar object at B, and $\delta^*$ the axial distance of the two images on the other side of the system; $n$ and $n^*$ the refractive indices of the media in front and at the back: then we have always

$$\frac{\delta^*}{\delta} = \frac{n^*}{n} \text{ M N}$$

*whatever may be the composition and focal length of the system, and in whatever position A and B and their images may be supposed.*

The quotient on the left-hand side of this equation expresses the *axial* amplification of a solid object extending from A to B, and shows this axial amplification (or the amplification of the *depth*) to be proportionate to the *product* of the *lateral* amplifications of the extreme layers of the object (or to the *square* of the geometrical mean of those amplifications).

If A and B are situated on the same side of the principal focus of the system (both in front and both behind), and their distance $\delta$ is taken shorter and shorter, the value of M must approach more and more to N, and the formula will give

$$\frac{\delta^*}{\delta} = \frac{n^*}{n} N^2,$$

and

$$\frac{\delta^*}{\delta} = \frac{1}{n} N^2,$$

if the medium at the back of the system is air ($n^* = 1$), as is the case with the Microscope.

Though the above general proposition has not yet been recorded, the fact that the axial amplification increases for short distances with the square of the lateral amplification has been noticed by various writers. The influence of this marked feature of optical delineation on the performance of optical instruments has not, however, been previously pointed out.

(2) The *depth of accommodation* ($\alpha$) in microscopical vision depends on the range of accommodation of the observer's eye in direct vision. If S denotes the longest and $s$ the shortest distance of distinct vision for a given eye, the range of accommodation is strictly defined by the expression

$$\frac{1}{s} - \frac{1}{S} = \lambda.$$

If, now, the equivalent focal length of an optical system is $= f$, and the object is in a medium of refractive index $n$, the absolute depth of the object which is embraced by the accommodation is

$$\alpha = n f^2 \lambda.$$

If N is the linear amplification of a virtual image projected by the system at a distance L from its posterior principal focus (which in the case of the Microscope is the "eye-point" above the eye-piece), we have

$$f = \frac{L}{N},$$

and therefore

$$\alpha = n \left(\frac{L}{N}\right)^2 \lambda.$$

(3) In order to determine the *depth of focus* ($\phi$) of a system which projects virtual images to an observer's eye, we must first define the degree of indistinctness which is allowed for these images. This may be done in the simplest way by indicating the visual angle under which the *admissible* circles of indistinctness (or dissipation-circles arising from the deviation of focus) appear in the virtual image. If $\omega$ denotes this angle of allowable indistinctness (and is expressed by its *arc* $- 1' = \frac{1}{3438} = 0 \cdot 000291$), $f$ the equivalent focal length of the total Microscope, or whatever other system may be in question, $a$ the *effective* numerical aperture, and $n$ the refractive index of the medium in which the object is, the *depth of focus* is determined by the equation

$$\phi = n \frac{f}{a} \omega$$
$$= n \frac{L}{N} \frac{\omega}{a}.$$

If the whole aperture-angle of a system is utilized by the delineating pencils (as is generally the case with low apertures), $a$ relates to the whole *aperture*. If, however, a narrower illuminating pencil is used, and not subjected to a considerable dissipation by the structure of the object, $a$ relates to the angle of the *admitted pencil* only.

The actual *depth of vision* is *depth of accommodation* ($a$) + *depth of focus* ($\phi$). We have therefore

$$\textit{Depth of vision} = n \frac{L^2}{N^2} \lambda + n \frac{L}{N} \frac{\omega}{a}.$$

The figures resulting from this formula are obviously not affected by the arbitrary value of the distance (L) of projection to which the figures of the amplification (N) may relate, because with one and the same system N is always proportional to L.

(4) The absolute *diameter of the field* which is visible in the Microscope depends on no other element but ($a$) on the equivalent focal length of the total system, and ($b$) on the *angle* of field of the *eye-piece*, which is the visual angle under which the clear diaphragm-hole of the eye-piece appears to the observer's eye. Let $u$ denote the *semi*-angle of field, $f$ the focal length, or N the total amplification of the Microscope for a certain distance L of the image, the linear diameter of the visible object-field is determined by the equation

$$d = 2 f \tan u = 2 \frac{L}{N} \tan u.$$

These are the dioptrical formulæ on the basis of which the examples of the foregoing discussion have been calculated.

**Abbe's Stereoscopic Eye-piece.**—We should have mentioned, in describing this at p. 298, 1st, that a special feature of the apparatus is its capability of being used with the highest powers; and 2nd, that

it is not necessary to cover up half of *each* of the eye-piece tubes, thus losing half the total amount of light. It is sufficient if *one* only (the lateral one) is half obscured, leaving the other free. As the normal division of light between the two tubes is two-thirds (in the axial) and one-third (in the lateral), the total loss of light is reduced to one-sixth.

The field of view of the axial eye-piece in this arrangement in any case necessarily appears brighter than that of the lateral one seen with the same eye; and in regard to this, Professor Abbe remarks * that the difference between the brightness of the two fields in binocular observation "is not only no defect, but on the contrary a decided advantage. For experience has long proved that to obtain a good stereoscopic effect it is only necessary that *one* image should be as perfect and clear as possible, whilst the other may, without appreciable disadvantage, be of sensibly less perfection.† It might therefore be anticipated that this would apply (as in fact it does) in the same way to difference of luminosity. Moreover, an additional fact must be taken into account—that the two eyes, especially of microscopists, always show unequal sensibility to light as the result of constant unequal use. The less used eye, whose acuteness of vision is always less than that of the one more frequently exercised, shows a greater sensibility to light, and the difference is so considerable that the less luminous image of the lateral eye-piece, when viewed with the less exercised (generally the left) eye, seems even brighter than the other when viewed with the exercised eye. The unequal division of the light is therefore a welcome element, as it serves to equalize this physiological difference. The observer has only to take care that the less used eye is applied to the lateral eye-piece."

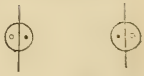
**Illumination for Binocular Microscopes with High Powers.**‡—Referring to the plan explained in the preceding note for half covering up only one of the eye-pieces, Professor Abbe says:—"On the other hand, there are cases—especially when high powers are used for binocular observation—where the simultaneous covering up of both eye-pieces may be of good service, whilst at the same time the loss of light may be fully compensated by the method of illumination. All stereoscopic vision with the Microscope, as far as it is anything more than mere *seeing with two eyes*, depends exclusively upon the unequal inclination of the pencils which form the two images, to the plane of the preparation or the axis of the Microscope. By uniform halving of the pencils, whether by prisms above the objective or by diaphragms over the eye-pieces, the difference in the directions of the illumination in regard to the preparation reaches approximately the half of the angle of aperture of the objective, provided that its whole aperture is filled with rays. By the one-sided halving we have been considering, the direct image is produced by a pencil the axis of which is perpendicular to the plane of the preparation, and the deflected image by one whose axis is inclined about a fourth of the angle

* Zeitschr. f. Mikr., ii. (1880) p. 207.
† Cf. Carpenter, 'The Microscope, &c.,' 6th ed. (1881) p. 36.
‡ Zeitschr. f. Mikr., ii. (1880) p. 207.

of aperture. With low powers, which allow of a relatively considerable depth-perspective, the slight difference of inclination, which remains in the latter case, is quite sufficient to produce a very marked difference in the perspective of the successive layers in the images. But with high powers the difference in the two images does not keep pace, even when both eye-pieces are half covered, with the increase of the angle of aperture, so long as ordinary central illumination is used. For in this case the incident pencil does not fill the whole of the opening of the objective, but only a relatively small central part, which as a rule does not embrace more than about 40° of angle, and in most cases cannot embrace more without the clearness of the microscopic image being affected, and the focal depth also being unnecessarily decreased. But as those parts of the preparation which especially allow of solid conception are always formed by direct transmitted rays in observation with transmitted light, it follows that under these circumstances the difference of the two images is founded, not on the whole aperture-angle of the objective, but on the much smaller angle of the incident and directly transmitted pencils, which only allow of relatively small differences of inclination of the image-forming rays to the preparation. It is evident, however, that when objectives of short focus and correspondingly large angle are used, a considerably greater differentiation of the two images with respect to parallax can be produced, if, in place of *one* axial illuminating pencil, *two* pencils are used oppositely inclined to the axis, in such a way that each of the images is produced by one of the pencils. This kind of double illumination, though it cannot be obtained by the simple mirror, can be easily produced by using with the condenser a diaphragm with *two* openings (Fig. 160), placed in the diaphragm stage (or carrier) under the condenser. We then have it in our power to use at pleasure pencils of narrower or wider aperture and of greater or less inclination towards the axis, by making the openings of different width and different distance apart. With diaphragms of this form (which can easily be made out of card), the larger aperture angles of high-power objectives may be made use of to intensify the stereoscopic effect without employing wide pencils, which are prejudicial, both as diminishing the clearness of the image and the focal depth. Of course, with this method of illumination *both* eye-pieces * must be half covered, in order that one image may receive light only from one of the two illuminating cones, and the other only from the other. The division of light in both the aperture-images will then be as shown in Fig. 161, and it is evident that in this case the brightness of the image for both eyes together is exactly the same as would be given by one of the two cones alone without any covering.

FIG. 160.

FIG. 161.



* That is, of the Abbe Stereoscopic Eye-piece.

The method of illumination here referred to—which was originally recommended by Mr. Stephenson for his binocular Microscope—has in fact proved itself to be by far the best when it is a question of using higher powers than about 300 times. It necessarily requires very well corrected and properly adjusted objectives if the sharpness of the image is not to suffer; but if these conditions are satisfied, it yields most striking stereoscopic effects even with objectives of 2 mm. and less focal length, provided the preparation under observation presents within a small depth a sufficiently characteristic structure."

We need hardly point out to microscopists the practical importance of the suggestion for on the one hand retaining the *advantage* of wide apertures to utilize the effects arising from *parallax*, while on the other hand neutralizing the *disadvantage* of such apertures in the loss of *focal depth.*

**"Working Distance and its relations to Focal Length and Aperture."** *—Mr. E. Gundlach has an article on this subject, which we regret not to be able altogether to follow, but we give his definitions and conclusions:—

"Working distance is the usual designation of the space between the object and the objective on a Microscope when the former is brought into proper focus; or, in other words, when the objective is brought to such a distance from the object that by means of the former an air-image of the latter may be formed at a distance of 10 inches.

"The working distance of an objective depends upon (1) the focal distance, (2) the aperture, (3) the number of lenses of which the objective consists, (4) the proportionate curvatures of the lenses, (5) the thickness of the lenses. . . . .

"The working distance of an objective may be expressed numerically, from a comparison of the theoretically longest working distance as unity, and the result may be called the 'numerical working distance.'

"As a single lens without thickness cannot be produced, the actual working distance of an objective will be much less than the unit of the numerical working distance. . . . .

"If $f$ is the focal length, $a$ one-half of the angle of aperture, $d$ the *actual* working distance, $n$ the *numerical* working distance of an objective, then

$$n = \frac{d}{f} \div \cos a.$$

* * * *

"(1) If two objectives have equal focal length and equal working distance but different angles of aperture, then the one with the larger angle of aperture has the greatest numerical working distance.

"(2) If two objectives have equal focal length and equal numerical working distance but different angles of aperture, then the one of the larger aperture has the shortest actual working distance. . . . .

"(4) The actual working distance of an objective is in direct proportion to the numerical working distance."

* Amer. Mon. Micr. Journ., ii. (1881) pp. 32–3 (2 figs.).

**Invention of the Binocular Microscope.**—Some controversy has recently taken place in America * on this subject, having been opened by a paper from Colonel J. J. Woodward, in which he complained that the claim of Dr. J. L. Riddell, Professor of Chemistry in the University of Louisiana, to be the inventor of the binocular Microscope had not been properly recognized in England.

It appeared, however, that Colonel Woodward in writing his paper had, by some strange accident, overlooked the fact † that both Mr. Stephenson and Mr. Wenham had publicly acknowledged Professor Riddell's priority,‡ and it may be added that the original papers of the latter were duly published in this country at the time.§

Colonel Woodward also objects to Dr. Carpenter having given to MM. Nachet credit which really belongs to Professor Riddell in regard to the form of binocular Microscope introduced by that firm, as to which, however, Mr. Wenham points out that M. Nachet's modification was a notable improvement and real advance upon Riddell's original idea.

We do not believe that any one in this country would venture to dispute the right of Professor Riddell to the title of "Father" of the binocular Microscope. Certainly, as the references given in the previous foot-note show, those who have subsequently so successfully improved upon Riddell's original ideas have never attempted to do so.

At the same time it is only fair to recall the fact that if the binocular Microscope had not advanced beyond the point at which Riddell left it, the use of the instrument would be very limited, and where now there are 100 binoculars to be found there would not then have been one.

**Priority of Invention.**—There is getting to be more and more of a tendency in modern times for authors or inventors who have at some period or other dealt with a given subject, to attempt to claim for themselves the credit of any modifications or improvements which may have been subsequently made by others, even although those improvements may for the first time convert an impracticable idea into a workable one. This has even been carried to such a point that suggestions which the authors themselves originally condemned and discarded as useless in practice have been again claimed, when it was subsequently shown (from another point of view) that they could be made available.

The question of oil immersion itself is a leading example of this, for although the use of oil was suggested at the same time as water, it was discarded in practice as not presenting any advantages, wholly and entirely through want of the knowledge that the apertures of oil or water immersion objectives exceed the maximum of dry

* Amer. M. Micr. Journ., i. (1880) pp. 221–30 (2 figs.); ii. (1881) p. 29. Amer. Journ. Micr., vi. (1881) pp. 14–15.

† Amer. M. Micr. Journ., ii. (1881) pp. 29–30 (Mr. Stephenson's reply). Amer. Journ. Micr., v. (1881) pp. 26–7 (Mr. Wenham's reply).

‡ Mon. Micr. Journ., x. (1873) p. 41.

§ See Quart. Journ. Micr. Sci., i. (1853) pp. 236, 304; ii. (1854) p. 18.

objectives in the same ratio as the refractive indices of the immersion fluids (1·52 or 1·33) exceed that of air (1·0). In the absence of that knowledge, the benefit of oil over water necessarily seemed to be very small—too small in fact to compensate for its disadvantages in use. The appreciation, however, of the increase in aperture—in the delineating power of the Microscope—at once changed the whole position and led to homogeneous immersion.

In fact, to no class do the following words of A. De Morgan* more aptly apply than to microscopists (italics as in original):—

"I have never found notice of any case of the theorem in any writer prior to Cavalieri. For this occasion I have cursorily examined the likely places of Maurolycus, Fernat, Sterinus, and Des Cartes, without finding anything which offered a chance if the search were pursued. But if, which is possible, any anticipation of a case or two should be discovered or even the theorem itself, unapplied, I should not the less give it the name of Cavalieri. I have come to a settled conclusion that *great points belong to those who made great points of them.* The history of mathematical discovery is vexed with never-ending disturbances arising out of claims of priority, which mean that this person threw the thing away before that person used it. In many cases it is by no means certain that this person ever saw in his own words or formulæ what that person enables *us* to see. Giving due moral blame to any one who consciously suppresses a hint which he knows he has taken, I consider that an inventor who is the first user has a position from which a hundred previous inventors cannot dislodge him, nor do anything but enhance his merit as the *inventor of the use*, most often the more difficult invention of the two."

### β. Collecting, Mounting, and Examining Objects, &c.

**Colouring Living Infusoria, &c.†**—M. A. Certes gives further details as to the solution of cyanine which he makes use of for colouring living infusoria.‡

He finds that with a solution of 1 : 500,000 the colouring power of the cyanine is still sufficient. Although stronger doses have been used, they have never exceeded 1 : 100,000. As distilled water is poisonous to infusoria, aqueous solutions of cyanine must be prepared with ordinary filtered water. Whether the solutions are aqueous or alcoholic, all decolorize more or less rapidly in the light, so that they require to be kept in the dark.

**Unmixed Cultivation of different Bacteria.§**—K. J. Salomonsen has adopted the following mode of obtaining unmixed cultures of different putrefaction-bacteria. An absolutely pure sowing was taken from putrefaction-specks in defibrinized ox-blood, which had been preserved and observed in capillary tubes. In order to obtain as large a number as possible of different forms, he chose (1) those

* Trans. Camb. Phil. Soc., xi. (1866) p. 200.
† Zool. Anzeig., iv. (1881) pp. 287–8.
‡ See *ante*, p. 527.
§ Bot. Ztg., xxxviii. (1880) pp. 481–9.

specks which presented the greatest possible differences in reference to time of incubation, rapidity of growth, and appearance; (2) specks from the blood of different individuals; and (3) he employed that blood only which contained a small number of specks, which were, therefore, at a distance apart. The piece of the capillary tube, the contents of which were going to be sown, was then separated under water by a strong pair of scissors, and placed in the culture-bulb, with the requisite precautions—viz. using all the instruments immediately after strong heating, to destroy the dust, &c. A bulb was used for this purpose provided with a rather short (4 cm.) and relatively wide neck, with only a small opening, closed by a wad. The wad was composed of a caoutchouc tube, which was so firmly closed for half its length by a small wad-stopper that it was slightly bulged. The tube was somewhat wider than the upper end of the neck of the bulb, that it might be placed on it without difficulty, but narrower than the lower part. After the requisite quantity of the nutrient fluid had been drawn into the bulb, and the latter closed, the definite purification and sterilizing were effected by boiling.

The author gives a tabular description of forty specks, and of the bacterial forms obtained from them, with information as to the period of incubation, rapidity of dissemination, &c. Six bulbs showed no development of bacteria. The remaining thirty-four contained at least seven different Schizomycetes—viz. four morphologically different bacilli in four bulbs, characteristic Streptococci in great chains and knots in four, and in twenty-six cocci which were easily divided into micrococci and mesococci. But the latter must also, in any case, include a variety of species, since a microscopic examination of each of the two groups revealed very considerable morphological differences. In some of the bulbs was nothing but diplococci, in others cocci of equal or unequal sizes, while in others they were of a comparatively gigantic size. A macroscopic examination also brought out great differences. With the motile bacilli there was always a diffused turbidity of the fluid, while the motionless cocci appeared as greyish or whitish specks, which formed peculiar figures on the walls; or they accumulated in masses at the bottom, or covered the wall as a connected easily destroyed pellicle.

These appearances recurred when the organisms in question were transferred to other bulbs with the same nutrient fluid. With reference to the rapidity of dissemination in the nutrient fluid (infusion of flesh), the micrococci were distinguished by their sluggishness.

**False Appearances produced by Hardening.**—Dr. G. H. Savage, of Bethlem Hospital, writes:—

"It is of the utmost importance that, in drawing conclusions from hardened specimens we should know what changes may be produced by the reagents used for preserving. As I am in some doubt as to the changes produced by spirit on nervous tissues, I write to ask the aid of brother microscopists as to the changes they have found in spirit-hardened specimens. I am more especially interested in the changes produced in nervous tissues by spirit, and I should be glad to

hear from others their experience on the matter, not alone in human tissues but in those of the lower animals.

My present belief is, that if nervous tissues are placed at once in spirit they will sooner or later show the presence of bodies which do not stain with carmine or logwood, and which, in some cases, do stain with osmic acid. These bodies are not all alike; some have a very suspicious foreign appearance, but others are so like some degenerations that they have been described as such. Some are of irregular rounded outline of varying size; some do take staining in a faint way, and some have a semi-crystalline look which confirms one's idea that they are not antemortem, but the result of the process of preparation. What I should specially like to know is if others have met them in similar conditions. Spitka of America described such bodies, and I have heard—but have not the references—that certain German writers recognize them as artificial.

In describing my experiences, I would say that they appear in nervous tissues when these have been in spirit for not less than two months, and that they are more common in the white matter, at all events at first; the more crystalline bodies, in my experience, do not occur till later. I believe that some of the non-staining bodies are due to a breaking up of the white matter of Schwann. Again, I believe that if the specimens are placed in spirit without being finely divided before hardening, they are more liable to produce these bodies. I shall be happy to provide any one with specimens if they will further investigate the matter."

**Hailes' Poly-microtome.**—Dr. Hailes sends us the following directions for using this instrument, which was described at p. 1036 of vol. iii.:—

When the microtome is used for freezing, remove the glass table, and cover the ice-jacket with felt or gutta-percha, to prevent absorption of heat from the atmosphere. Oil the screw and plunger, to prevent them becoming fixed by the freezing (too much oil interferes with freezing); screw the cylinder into position on the bed-plate. Enclose the top with a tightly fitting cork, to prevent the entrance of ice, &c. Put on the hopper cover, and fill the ice-jacket with very finely powdered ice and coarse salt, through the hopper, and stir the contents by rotating the hopper cover. In a few moments the cylinder will be cooled down to freezing-point. Remove the hopper lid, and cork and fill the cylinder two-thirds full with mucilage acacia, British pharm.; then replace the cork and hopper lid, and stir for a few moments.

When a white frozen film has formed at the periphery, then introduce the previously prepared specimen into the mucilage in the well of the microtome, holding it against the advancing film of ice until it becomes fixed in the desired position; then pour in a little more mucilage so as to cover it completely, recork the cylinder and replace the hopper lid, and stir, adding ice and salt as it becomes necessary, until the specimen is solidly frozen.

When perfectly frozen, exchange the hopper lid for the glass table, which has previously been cooled by contact with ice, then cut in the

usual way, an assistant working the lever alternately with the cutting. The thickness of the cutting is controlled by the regulator, as shown on the index; the thickness most generally employed is $\frac{1}{1200}$ of an inch. (These measurements are approximal.) The temperature at which the best results have been attained has been where the surrounding atmosphere was about 40° Fahr. If during cutting the tissue becomes softened, it must be refrozen; this is accomplished by disengaging both pawls, and causing the plunger to descend rapidly by turning the micrometer screw direct by the knob on the ratchet-wheel. The cylinders being interchangeable, the tin cylinders are slipped over the brass ones previous to interchanging them; thus no delay takes place. Two hundred sections have been successfully cut in a single minute, but a more moderate rate of about 100 per minute is recommended.

Figs. 162 and 163, one-fourth original size, show the instrument arranged for freezing with ether spray, rhigoline, &c. In Fig. 162,

FIG. 162.

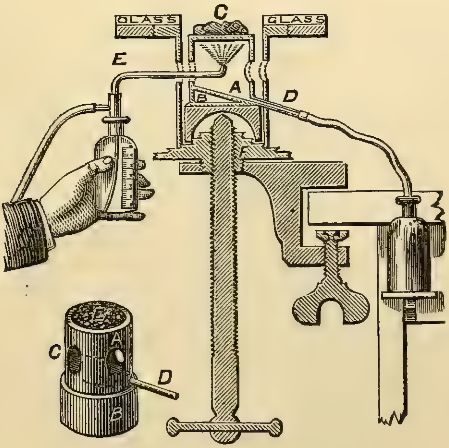



FIG. 163.

A is the zinc cylinder or spray chamber; B, false or sloping bottom for conducting condensed ether; D, exit tube leading to collecting bottle; C, object to be frozen; E, ether spray apparatus; F, pyramidal bed-plate, &c. In Fig. 163, A is the zinc cylinder; B, plunger of microtome; C, opening for spray instrument, &c.; D, exit tube for collecting condensed ether; E, roughened top, to facilitate the retention of the frozen object in position.

**Williams's Freezing Microtome.**—This (Fig. 164), the design of Mr. J. Williams, and made by Messrs. Swift, consists of a wooden "tub" pitched inside (holding about 2 pints) to receive the freezing mixture, having in the centre a brass standard, into which screw the brass circular plates on which the material to be frozen is

put. One of these plates is shown in place with three others in front, the hollow one for hard and other substances which require fixing in some kind of cement, &c., and the oblong one for preparations of larger size. The vessel is closed by a top with a glass surface, having a central hole through which the circular plates project slightly. The knife—the edge of which only comes into contact with the substance cut—is fixed into a triangular frame, which moves freely on the glass surface. By the three screws at the angles the frame, and with it the knife, can be raised or lowered for adjustment in any desired plane. The other two screws attached to the frame are for supporting the knife, which has two notches fitting into grooves near the points of the screws. A third horizontal screw presses the knife against the first two screws and keeps it tightly in place. The screw seen at the left-

Fig. 164.


hand side of the ice vessel is for the purpose of clamping the top, and the indiarubber tube carries away the drainings as the ice melts. It is claimed that this instrument will keep the preparation in a frozen state for hours after once charging with ice and salt, and readily cuts sections $\frac{1}{1000}$ inch thick.

The method of using the microtome is as follows:—

Remove the cover and fill the chamber with equal parts of pulverized ice and salt, care being taken not to allow the mixture to touch the under side of the cover, which, when replaced, must be firmly secured by the clamp screw for that purpose. The substance to be cut must be placed on the surface of one of the circular plates, and surrounded with a little common gum-water, which readily congeals and thus holds the specimen firmly in position, which will solidify shortly

after the gum has frozen. The edge of the razor must be elevated to the required height for cutting the section by means of the three screws supporting the frame. After the first cut, each end of the razor must be again presented to the surface of the specimen, when either end of the blade can be adjusted by one of the centre screws until its entire length is level, then by turning the larger screw at the apex of the frame it can be lowered for each successive section required. One entire revolution produces a section $\frac{1}{100}$ of an inch in thickness.

The screw-head being divided into sixths, one division gives a section of $\frac{1}{600}$ of an inch, and thinner ones can be produced by proportionately turning the screw. Substances that have been previously prepared in spirit or chromic acid require to be steeped in syrup for twenty-four hours beforehand, otherwise they will not readily congeal. It is advisable to cover the apparatus with baize to facilitate the operation of freezing. When it becomes necessary to sharpen the razor, it can easily be removed for that purpose, but when replacing it, care must be taken to arrange it parallel and with the edge a trifle lower than the back, so as not to deface the preparation. Too much force must not be exerted in clamping the razor in position, as the blade is liable to twist or bend.

Zeiss's Microtome.*—Dr. Körting describes this instrument, the first incentive to the construction of which originated with Professor Lichtheim as a desirable improvement on the Leiser form.

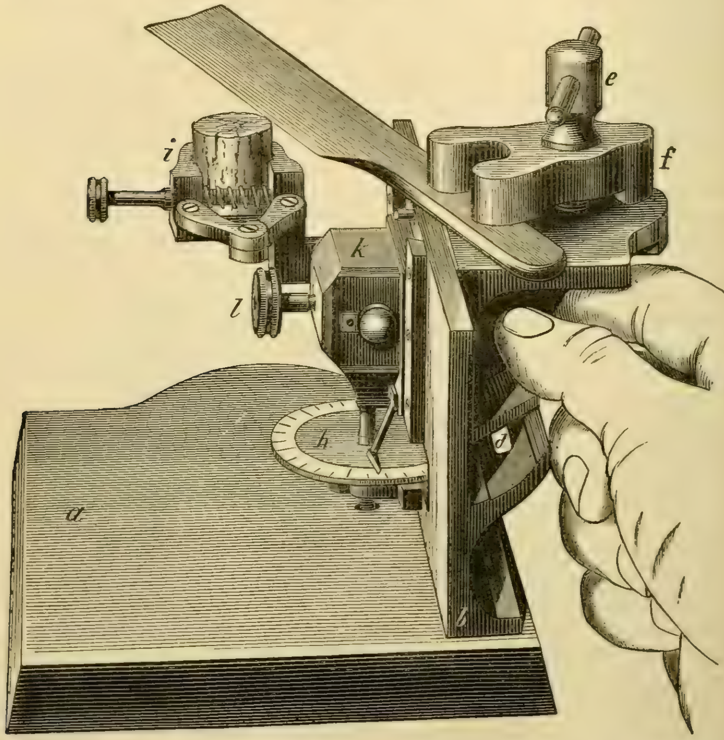
The microtome (Fig. 165) consists of a broad cast-iron foot *a*, to which a brass upright *b* is screwed. To this is fixed, on the right, a piece *d*, which is planed smooth, and allows the knife-carrier (14 cm. long) to slide along it. To prevent it slipping off, there is a groove, in which moves a button attached to the under side of the knife-carrier. The knife is fixed by the screw *e*, which clamps the handle between two brass plates, the surfaces of which are plane and smooth. When the upper plate *f* is turned round *e* towards the left, the knife can easily be taken out and put in. The knife itself is so shaped that it can be held in the hand and used to make free-hand sections if wanted. It most resembles the knife of Fritsch. The blade can be fixed at angles between 62° and 24° to the sagittal axis of the object. As the latter angle, especially when the object is very delicate, does not exclude the pressing action of the knife to the extent desired, Dr. Körting prefers for his instrument a knife whose blade forms an obtuse angle of 150° with the handle. This can be placed at such an acute angle with the object that 5 cm. out of the 7 cm. of the knife blade can be drawn through an object 7 mm. in diameter.

To the left side of *b* a movable plate is attached, sliding between two flanges, and to it the object-clamp is fastened. It is elevated by a micrometer screw, a complete turn raising the object-carrier 0·3 mm. The graduated head *h*, divided into 30 degrees, marks hundredths of a millimetre in elevation. The clamp *i* can be turned about a pivot

* Jen. Zeitschr. Naturwiss., xiv. (1880) p. 193.

in the block *k* (fixed to the movable plate), so that the cutting surface of the object in the clamp can be presented more or less obliquely to the blade of the knife. The binding screw *l* fixes it in the various positions. The clamp may be turned down so far as to allow the object to be removed without coming too near the knife. If required, a box is provided as well as the clamp, in which delicate objects may be imbedded.

Fig. 165.




Dr. Körting considers the fixing of the clamp a most essential improvement. When perfectly fixed, it stands off at such a distance that a vessel can be placed underneath so as to catch all the drops that fall, without wetting the other parts of the instrument or the hands, &c. This is very important for those who work in the house.

**Preparing Coal Sections.**—Professor P. F. Reinsch gives the following directions for preparing sections of coal: *—

A plane cut, as in rock and mineral sections, generally is not serviceable; the cut must be made in relief. Thus only the different

* See transl. in Amer. Natural., xv. (1881) pp. 498–9.

forms can be brought out, as according to their hardness each form will become more or less transparent, since the softest parts will be worn faster, and hence be finally thinner and more transparent than the more resisting forms. Sections parallel to the bedding are made without difficulty; not so sections at right angle. Much precaution is to be exerted with these. Cut the raw plate with a steel saw 4 mm. thick, 15 mm. square. Make a plane cut as usually in rock sections, but using only the finest emery (polishing emery) or precipitated carbonate of calcium. Then rub the surface gently in all directions with a cork plate (perfectly soft and no grains) 10 mm. square, and moistened with a drop of glycerine. This treatment produces the relief. Frequent examinations must be made under the Microscope, to observe the point where the desired transparency has been reached (not less than 0·01 mm.). In some cases, as for trichites and grammites, it is best to warm the raw plate and saturate it with a mixture of wax and paraffin. When attaching the plate to the support, it should neither be heated too long with the balsam nor too short a time, the first excess causing the plate to warp, crack, and inducing a partial alteration of some of the coal constituents; too little boiling causes the plate to detach itself from the support during the process of grinding. Chemical treatment with acids or alkalies is not advisable.

A microscopic image of the condition of things in a coal section may be obtained by closely inspecting a sharp cut through a compressed ball of hay. Here the innumerable plant individuals are cut in every direction. The different sections of the same plant have often so little in common that an identification of the species is extremely difficult. This is true of a microscopic coal section; and only the comparison of very many specimens will establish the common characters of the forms. Professor Reinsch's conclusions, to which we referred at page 836 of vol. iii., are drawn from 1200 perfect sections.

**Simple Method of making Rock Sections.***—The process of reducing stone and other hard substances to thin sections for microscopical examination by the methods usually employed by amateurs is, Mr. W. C. Brittan considers, both tedious and laborious, requiring a great amount of patience and some ingenuity, with a commonly unsatisfactory result; and he therefore gives some suggestions from his own experience that are very efficacious with all substances not too hard to be reduced by grinding with emery.

Take a piece of plate glass—3 × 4 inches is a very convenient size—set in a block of wood; a circular piece of inch-thick pine, with three screw-heads placed triangularly underneath, will be found to give it great solidity upon the table, a qualification very desirable in doing delicate work. Upon this piece of glass, with emery and water, grind one side of a glass slip to an evenly ground surface. Next, take the stone or other substance from which a section is to be made, and in the same way grind down one side of it to a suitable face.

* Amer. Journ. Micr., vi. (1881) p. 12.

Place a drop of balsam on the ground surface of the slide, pass it over the flame of the lamp until sufficiently hard to chip when cold; while still hot, place the stone in position, press down as close as possible, being careful not to enclose air-bubbles underneath. It is also important that the object be perfectly dry, as any moisture would cause air-bubbles when placed in the hot balsam. This part of the process should be carefully done; for the object is now on its final resting-place, and is not again to be disturbed. When the slide is cold, with alcohol, or ether, clean away all the surplus balsam, return to the glass slab, and grind down the other side of the section as thin as desired, using the finest grade of emery in finishing. In this way sections of almost any size and uniform thickness can be made perfectly free from breaks and flaws.

After the slide has been thoroughly washed and dried, it is ready for the cover-glass. Place a drop of turpentine upon the object, allowing it to spread entirely over it without excess; this expels the air and prepares it to receive the balsam. Next put a drop of balsam on the cover-glass, and harden over the flame as before, only not quite so hard this time; let it cool a little, turn it over, and place the drop, which hangs suspended, upon the centre of the object; heat the slide again very slowly over the flame until the cover gradually settles to its place, then gently press it home. When cold, clean away all the surplus from around the cover, wash thoroughly with soap and water, and the slide is finished. This process cannot be followed with any other than the ground-glass slip. If the ordinary slip be used, the object must be transferred from the glass upon which it is ground to the slide upon which it is mounted, which, in very delicate sections, is most difficult to do without breaking.

Tin-foil Cells.*—Mr. A. H. Chester commends cells cut out of different thicknesses of tin-foil and finished on a lathe.

The object is first fastened to the slide (centered on the turn-table) by means of a weak solution of gelatin, gum-water, or Brunswick black. For very small objects a small circle of the gelatin is turned in the centre of the slide, and then allowed to dry. The objects are arranged on the spot, and then, by carefully breathing on the slide, they are fixed in position. If larger objects are to be fixed to the slide, a spot of gelatin or gum that the object will entirely cover is put on, and after drying, the object is fixed in the same way. For larger and heavier objects a circle of Brunswick black is turned, and after it has been thoroughly hardened by heat, so that when cool a needle point will not mark it easily, the object is arranged on the spot and fastened by warming again.

In whatever way the object is fastened, the next thing to be done is to lay the slide on the plate and heat it until it is perfectly dried and ready to be covered.

The slide is then centered on the table, and a circle of shellac, which has been thickened and coloured with Chinese vermilion, is run around the specimen, at such a distance from it that its inner

* Amer. Mon. Micr. Journ., i. (1880) pp. 233–4.

edge is just larger than the cell to be used. The cell is then laid on, centered, and pressed hard to set it. If the slide is slightly warm and the cement thick, it will not run at all, but will hold the cell firmly in place, so that the cover can be put on at once. If it is thin, it must first be allowed to harden somewhat. When ready, as it will be in a few moments if properly managed, a ring of the same cement is run on the cell, and the cover is then laid on, pressed down, clipped in position, and the mount laid aside to harden. It is well in an hour or so to remove the clip and run cement in the joints between cover-glass cell and slide, in order to be certain that no air-holes remain. It can then be reclipped, and set aside until the cement is perfectly hard. The mount is complete, and will last a long time if proper care is taken of it. For security it is well to put on additional rings of cement more elastic than the shellac, and to make a final finish for the sake of appearance. A ring of white zinc cement should therefore be put on, which completely fills up the joints, and makes a smooth surface from cover-glass to slide. This must harden several days, and the slide is then complete, unless additional rings are run on for a finish.

In making the rings on slides it is not always easy to make the edges true, and sometimes the cement spreads too far. In such cases they should be turned down with the point of a knife until they suit. If the cement is taken just at the right time this is easily done, and it improves the appearance very much.

Mr. A. Y. Moore also commends * tin-foil cells, which he makes as follows :—

Flood a clean *warm* slide with lacquer (a weak solution of shellac and alcohol), allowing it to drain from one corner. The heat of the slide causes a rapid evaporation of the alcohol, leaving a film of shellac on the slide. Prepare a piece of clean flat tin-foil, a little larger than the outer diameter of the cell required. Heat the slide till the film of shellac is melted, taking care not to boil it. The foil should then be placed upon the centre of the slide, and firmly pressed against it, so that it may adhere at all points. In a few minutes the slide will be cool, and the film firmly adherent. It may now be placed upon the turntable, and with the point of a sharp knife-blade two clean cuts should be turned through the foil, one for the outer and one for the inner edge of the cell. As soon as the cuts are made, the superfluous tin should be scraped away and the slide cleaned with alcohol; it is then ready for use. The cement is hard, and no time need be wasted in waiting for it to dry, as in ordinary cells.

**Wax Cells.**†—Mr. W. H. Gilburt finds, as the result of using wax for a long time past, that dewing is avoided by building up the cells. He spins up the wax on the slide, using melting wax and a turntable. The cover adheres by itself, and he has not found any condensation of moisture whatever, the heating of the wax seeming to get rid of the volatile element. In finishing off, it is best to use first a thin coating

* Amer. Journ. Micr., vi. (1881) pp. 29–30.
† Journ. Quek. Micr. Club, vi. (1881) pp. 215–6.

of oxide of zinc in gum-water and then put on the finishing coating afterwards.

**Wax Cells—Decomposition of Glass.**—Herr E. Weissflog of Dresden writes to Professor Hamilton L. Smith * that he considers that wax cells must be thrown aside. He has a number of preparations of diatoms from Eulenstein made with wax cells which are completely spoilt and the covers loose. Herr Lindig of Dresden, who has had much experience in mounting, and has for many years endeavoured to find some reliable cement, has arrived at the result that shellac is the best, and he now uses nothing else.

At the same time, Herr Weissflog is decidedly of opinion that the spoiling of preparations is partly due to the glass. He has slides of the best plate-glass, and when they are packed away the outer surface appears after a time covered with moisture. He has also often found numerous crystals on Chance's cover-glass, which appear to come from a kind of sweating or decomposition of the surface.

**Arabin for Mounting.**†—Mr. H. J. Waddington says that "arabin," or gum arabic from which all impurities have been removed, will be found valuable to microscopists for attaching diatoms, &c., the ordinary gum arabic presenting a granular appearance.

To obtain arabin for microscopical use clear and white gum arabic should be selected, and dissolved in distilled water to the consistency of thin mucilage. On filtering and pouring the filtrate into rectified alcohol, well shaking it, the arabin separates as a white pasty mass. It must be placed on filter paper and washed with alcohol (not methylated spirit) until the washings are free from water and the alcohol comes off as pure as it went on. Allowed to dry, the mass (other than the edges of the surface) will be a perfectly pure white powder. Though troublesome and expensive to prepare in consequence of the quantity of alcohol required, a little of it goes so far that practically it costs little.

For use the arabin should be dissolved in distilled water to any required consistence, and passed twice through filter paper previously washed with distilled water. It may then be placed on the slips, drained, allowed to dry, and the slips put away for use. In this condition and with ordinary precautions it may be preserved indefinitely.

**Mounting Diatoms in Substances of High Refractive Index.**—In confirmation of Mr. J. W. Stephenson's views on this subject,‡ Professor Hamilton L. Smith § reports that slides of *Amphipleura pellucida*, *P. angulatum*, and *Rhizosolenia styliformis*, mounted in monobromide of naphthaline (ref. ind. = 1·658) by E. Weissflog,‖ show that there is very little difference, in regard to the visibility of such

* See Amer. Mon. Micr. Journ., ii. (1881) p. 49.
† Journ. Quek. Micr. Club, vi. (1881) pp. 199–200.
‡ See this Journal, iii. (1880) p. 564.
§ Amer. Mon. Micr. Journ., ii. (1881) p. 49.
‖ See this Journal, *ante*, p. 151.

transparent diatoms, between dry mounts and those in monobromide. The markings of *P. angulatum* are almost invisible in balsam, but in the monobromide they are as readily seen as on the dry frustule, and also the same peculiar colour of the dry valve. *Amphipleura pellucida* is quite as distinct and easily resolvable as in a dry mount. Herr Weissflog adds that the distinctness of the diatoms as compared with the balsam mounts is very great, and is especially noticeable in *Rhizosolenia*.

**Mounting Marine Algæ.***—The Rev. J. D. King says that the best medium for preserving the colour, either of marine or fresh algæ, so far as he has tried it, is a preparation suggested by Dr. Munson, of Otisco, N.Y.: chloral hydrate, 15 grains; water, 2 ounces.

The tendency of this fluid is to make objects preserved in it more transparent; but he has slides of green algæ mounted a year ago, which yet retain the brilliancy of living colours, and appear in striking and favourable contrast with those mounted in other media. It needs a further trial before pronouncing safely upon its merits, but he believes it to be worthy the attention of algologists.

**Mounting Starches.**†—Mr. E. Hunter considers that the method described at page 536 is not a good one, as heat alters the form of all starches. When required for polariscope objects, thin dammar and thin balsam are perhaps the best media, used cold and left to harden spontaneously. By this, wheat-starch and many others which do not polarize under ordinary circumstances show well. For ordinary examination, weak solution of ammonia is one of the best media.

It is also pointed out ‡ that an excess of heat will cause the granules to burst and disappear.

**Mounting Opaque Objects with Beeswax.**§ — Mr. H. Morland gives some suggestions for mounting opaque objects.

He melts down in an oven bleached beeswax (in cakes) with ultramarine or vegetable black, stirring the whole well together. Too much ultramarine must be avoided, as it will crystallize out on the surface of the wax. The blue wax gives a most pleasing background for dead-white objects, and the effect is enhanced by illuminating the wax from beneath.

The wax is melted in a cell on the slide over a spirit lamp, when it will form a cup-shaped bottom. It should be cooled quickly by placing the slide on metal or marble. The objects are fixed not by any cement, but by simply placing the slide upon a block of iron heated to about 140° F. If the object is large it may require to be slightly pressed into the wax. The objects appear by this method to be merely laid on the surface of the wax, and there is no danger of an objectionable "wall" ever appearing round the object if the cover has been hermetically sealed with the wax (using white cement afterwards).

The "wall" is generally caused either by the background not being sufficiently dry or by the vapour of the solvents of the cements

* Amer. Journ. Micr., vi. (1881) p. 58.
† Sci.-Gossip, 1881, p. 135. ‡ Ibid., p. 160.
§ Journ. Quek. Micr. Club, vi. (1881) pp. 196–8.

used for fixing the cover passing under it and re-dissolving the background, a remedy for which is to employ a background having a solvent different to the cement used for fixing the cover.

**Dry Mounting.***—Mr. F. French has contributed to the Postal Microscopical Club a slide mounted in a style which promises to be useful for certain kinds of opaque objects which will bear occasional exposure to the dust and moisture of the air, and which are best viewed without the intervention of a cover-glass. The slip is composed of cardboard, cut to 3 × 1 inches, the required thickness in each case being obtained by building up a sufficient number of thicknesses, gummed together. The centres are punched out as from the paper covers for glass slips, and the object is fastened at the bottom of the cell thus formed, either upon mica fastened at the bottom of the cell, or upon a bottom card not punched like the rest. The object is covered by a rectangular brass sliding-plate below the upper card, the card next below being cut away to receive it and to allow it room to slide entirely away from sight when desired. A pin-head is rivetted and soldered into this brass plate, and projects through the upper card, appearing near the right end of the finished mount, through a longitudinal slot that permits it to be pushed toward or from the other end of the slide, and thus to carry the brass plate over the object or away from it. The whole mount is finished by covering with paper in the old style.

**Semper's Method for Dry Preparations.**†—Herr Semper recently exhibited to the Würzburg Society some zoological and anatomical preparations which had been prepared by a new method for dry preservation.

After being hardened in a solution of chromic acid, the objects are placed in alcohol to remove the water, and afterwards steeped in oil of turpentine and finally dried. The tissues whilst drying are permeated by innumerable small air-bubbles, and in consequence the preparations retain their original form without sensibly shrinking, whilst in colour they assume a white tint similar to that of a gypsum model. The finished preparation, which is almost pure white, and which possesses a firm leathery consistency, may be painted with colours in parts as may be required for teaching purposes. The preparations produced were partly complete animals—mussels, Annelida, &c.—with the viscera of various vertebrate and invertebrate animals. A preparation of a cat's eye showed that, after drying, the position of the parts—the lens, ciliary processes, &c.—underwent no change. A microscopical preparation of brain treated on this method proved that still simpler microscopic relations were retained after the drying, and —particularly with carmine colouring—could be distinctly recognized.

Herr v. Kölliker pointed out the advantage to be derived from this method, especially the possibility of adapting the preparations for special demonstration by painting.

* Amer. Natural., xv. (1881) p. 346.
† Verh. Phys.-Med. Gesell. Würzburg, xv. (1881) SB. ix.

**Talc for Cover-glasses with High Powers.**—Mr. W. S. Kent found * that in using the high-power objectives necessary for the examination of the minute collar-bearing Flagellate Infusoria, the chief obstacle was presented by the necessity for very thin cover-glass, which causes both inconvenience and loss of time on account of its extreme brittleness. Where the objects under examination are attached to more solid substances, such as the stems of water-plants, this rigidity and brittleness of the cover-glass hampers progress in a most provoking manner, and materially restricts the limits of clear vision.

The unsuitability of ordinary cover-glass for such investigations led the author to provide a substance that has been productive of the most satisfactory results. This was the ordinary talc, formerly universally employed by microscopists, and now extensively used for gaselier shades. This, with a little practice, may be split into laminæ of such extreme tenuity that they may be blown away with the lightest breath, while for perfect evenness and transparency they will compare favourably with the finest manufactured glass. With the employment of these talc-films the investigation of Infusoria with the $\frac{1}{16}$, $\frac{1}{25}$, or even the $\frac{1}{50}$-inch objectives becomes, Mr. Kent says, a comparatively easy task. The material possesses the further considerable advantages of bending readily and permitting the objective to be brought close down on the more remote objects in the field, while it may be cut with the scissors to any required size or shape.

**Micrometrical Researches on Contracted Muscle.**†—Professor T. W. Engelmann publishes an interesting series of measurements, illustrating the relative lengths of the principal constituents of muscular fibres during contraction. His observations were made chiefly on beetles. They confirm and much extend, from a physiological point of view, the histological results of Foettinger. ‡ Against Ranvier, Engelmann maintains the superiority of insects to vertebrates for these studies. Every student of the more minute phenomena of muscular action will read through the whole of this short paper, with its tables too numerous for quotation.

**Prismatic Action of certain Microscopic Objects.** §—The colour-changes presented in the Microscope by various substances (chiefly mineral) of uneven surface, when immersed successively in liquids of different refracting power, have been made by Herr Maschke the basis of a method of distinguishing substances. Such changes may be had, e. g. with small glass particles, observed in water, in oil of almonds, and in mixtures of the latter with oil of cassia. The dark and the bright parts of the image show different series of colours. That the effects are simply due to prismatic action of the object appears from the fact that they may be got without the Microscope, by looking through a tube at a piece of rock-crystal in water, &c.

For mineral objects Herr Maschke used five liquids—amylic

* Kent's 'Manual of the Infusoria,' i. (1880) pp. 115–16.
† Pflüger's Archiv, xxiii. (1880) pp. 571–90.
‡ See this Journal, iii. (1880) p. 612.
§ Wied. Ann., No. 12. See 'Nature,' xxiii. (1881) p. 398.

alcohol and glycerine, besides the three just named. By various mixtures of these a series of liquids is obtained, giving any desired index of refraction from 1·333 to 1·606. (Coloration begins when the refraction of the liquid is near that of the object; when the former greatly exceeds the latter a certain stability of colour appears.) The method is not applicable to bodies opaque in the Microscope, or having too strong colours of their own; nor yet to bodies having a greater index of refraction than oil of cassia. It may, too, prove difficult sometimes to find a liquid sufficiently indifferent to the object. Herr Maschke indicates how the refractive indices of substances may be compared by his method, and (a more difficult task) numerically determined. He also gives a number of his own determinations.

**Carpenter's 'The Microscope and its Revelations.'***—The sixth edition of this book has just been issued. It is revised, and brought down to the present date by numerous additions, including descriptions of the more recent forms of microscope-stands, of swinging substages, oil-immersion objectives, and additional accessory apparatus, and the chapter on preparing, mounting, and collecting objects has been re-written.

In the sections relating to Protophytes, much new matter has been introduced in regard to the *Schizomycetes* or *Bacteria*, the *Myxomycetes*, and other organisms which occupy the border-ground between vegetable and animal life. To the Protozoa large additions have been made, under the heads *Monerozoa*, *Rhizopoda*, *Infusoria* (especially the *flagellate* and *suctorial*), and *Radiolaria;* and the section on *Sponges* has been entirely re-written. Some additions have also been made in regard to the applications of the Microscope to geological inquiry.

Three important points of microscopical optics are dealt with for the first time in any English treatise on the Microscope.

1st. An account is given of the modern theory of the estimation of aperture, in regard to which it is pointed out (p. 854) that "Professor Abbe's investigation has made it clear that the aperture of an immersion objective may exceed the maximum of that of a dry objective."

2nd. Professor Abbe's diffraction experiments are explained in detail, of which Dr. Carpenter says (p. 188): "We thus have now for the first time the scientific *rationale* of the fact which has long been practically known, the relation of the 'resolving power' of objectives to their angle of aperture."

3rd. With respect to wide-angled objectives, Dr. Carpenter says (p. 191) that "it is clear that the representations of minute structure given by objectives of widest aperture are more trustworthy than those given by those of narrower."

We have noted a few errata for the next edition:—

P. 18: Although Amici, and those who succeeded him, failed to appreciate the importance, as regards larger apertures, of increasing the refractive index of the immersion fluid (first embodied in homogeneous immersion), he should nevertheless be credited with

* 882 pp. (26 pls. and 502 figs.).

the original suggestion not only of water for immersion lenses but of oil also, the dates being: *Oil immersion*, Amici, 1844; Oberhäuser, 1845; Wenham, 1870.* *Homogeneous immersion:* Stephenson, 1878.

P. 33: Professor Riddell should be credited with the original invention of the stereoscopic binocular.

P. 191: The expression "angular aperture" (here and at other places in the earlier parts of the book) should be replaced by "aperture," as a synonym for which it is in fact used by the author, "angular aperture" (and its equivalent "angle of aperture") being, as shown by Dr. Carpenter at p. 852, *one* of the factors of aperture.

P. 193: The quotation "minute details are concealed or destroyed till the aperture is sufficiently reduced," should be omitted, as it conflicts with the author's own more correct view, quoted above, that minute details are more perfectly shown by objectives of widest aperture.

The statements at pp. 193 and 196–7 that there is an inherent incompatibility between good definition and large aperture should be deleted, as it is now known both from theory and experiment that the definition of objectives of the widest apertures (1·47 out of a possible 1·52) is as perfect as with those of less aperture. The wider the aperture of an objective, the greater the technical skill which is required on the part of the practical optician; but the notion that as the aperture of an objective is increased its defining power must necessarily, either on theoretical or practical grounds, be impaired, happily belongs to a closed chapter of microscopy.

It may be safely said that there is no book in the English or any other language which more completely combines all that the amateur worker with the Microscope requires.

**The Microscope and the Origin of the Anatomy of Plants.**†—Dr. W. J. Behrens, in a paper under this title, gives an historical sketch of the researches of the early vegetable histologists, more especially Cesalpini, Malpighi, and Grew.

The paper also contains a short history of the simple and compound Microscope, terminating with the achromatic Microscope, the invention (or rather "construction") of which is—following Harting—put as early as 1807 by Van Deyl, a Dutchman, afterwards improved by Selligue, Chevalier, and Amici between 1820 and 1830. Van Deyl's objective was made of two biconvex crown-glass lenses, with an intermediate biconcave of flint glass. Such an objective had, of course, a great amount of spherical aberration.

**Huberson's 'Journal de Photographie et de Microscopie.'**—The first series of this journal (6 vols.) was exclusively devoted to photography, but last year a second series was commenced under the above title, with the intention of including also Microscopy, "at first elementary and restricted to the more ordinary notions, then more advanced, and finally as complete as the competence of the editor and the taste of the readers will allow." The combination of photography

* See this Journal, ii. (1879) p. 490.

† 'Gaea,' xvi. (1880) pp. 480–9, 536–43, 675–80.

and microscopy is justified on the ground that "founded on optics and on the observation of objects of nature or of human art, they are in close connection, each requiring only an easy apprenticeship for those who are already familiar with the other."

The first volume (12 Nos., July–December) contained 84 pages, but in future one part of 16 pages will be published quarterly, the saving thus effected being applied to creating and maintaining a gratis circulating library for the subscribers.

**"Société Francaise de Microscopie."**—The title-page of the first volume of the preceding journal announced that it was the "Bulletin de la Société Française de Microscopie," and we were for the moment under the impression that a Microscopical Society had at last been established in France. It appears, however, by an announcement in the journal that the constitution of the society is a novel one, as it consists simply of the subscribers to the journal, who are formed by the editor into two groups, one being called the "French Society of Microscopy," and the other the "Photographic Society of France," each with a central group in Paris and local groups wherever the number of subscribers is sufficient.

Of the constitution of the society only the 1st and 3rd articles of the statutes are at present published:—

"Art. 1. There is founded, under the name of the "Société Française de Microscopie," from among the French or foreign subscribers to the 'Journal de Photographie et de Microscopie' who assent to these statutes, a society for observation, for communications, and exchanges, having Microscopy for their object. It is administered by the director of the journal, who bears the title and performs the duties of secretary of the society.

"Art. 3. The members of the society pay neither entrance fee nor periodical subscription. Nevertheless, each of the groups of which the society is composed may impose useful expenditure on the group or on the society (!). This expenditure can only be voted for a year."

**Micrographical Mineralogy.**—Under this title the French Ministry of Public Works has published* a *livre de luxe*, in 4to, with 509 pages and 55 plates, by MM. F. Fouqué and A. M. Lévy. There are opening chapters on the "utility of the microscopical examination of rocks," and on the "history" of such examinations (referring more especially to those of Leeuwenhoek in 1690, Baker and Ledermuller in 1764, Daubenton in 1794, Dolomieu and Fleuriau de Bellevue in 1800, and others since that date), with directions for "preparing material," on Microscopes for petrological work, and several chapters dealing very exhaustively with the optical properties of minerals. These are followed by directions for the qualitative analysis of rocks, and for extracting elementary minerals from rocks, the first part concluding with an explanation of the deformations and imperfections found in the minerals. The second part (pp. 147–475) is occupied with a detailed description of the various minerals, commencing with quartz. A copious bibliography of 27 pages is appended.

* Part of the 'Mémoires pour servir à l'explication de la Carte Géologique détaillée de la France.'

The plates, most of which are coloured, represent the different minerals described in the work as seen under the Microscope, i. e. not isolated but in their natural association in rock sections. These plates are upon a novel and ingenious plan. To indicate each particular mineral in the sections would ordinarily require the use of letters or numerals, interfering with the appearance of the plates. This is avoided by attaching to each plate (at its upper margin) a piece of transparent paper the size of the plate, containing the *outlines* of the different minerals shown. These outlines being exactly superposed on the plate, and being identified by figures referring to an explanatory table giving the names of the minerals, any one can be at once identified by allowing the transparent sheet to cover the plate.

Some of the plates are "photoglypts" from sections under the Microscope. In all the plates the principal planes of the Nicols when crossed are supposed to be parallel to the margins of the paper. When not crossed the principal plane of the polarizer is supposed to be vertical. The colours of polarization are those shown by the ordinary thickness of the authors' slides, viz. ·01–·03 mm.

**Stirling's Practical Histology.***—This book is divided into two parts—"Introduction" and "Practical Work."

The first (38 pp.) contains histological requisites, general directions on the use of the Microscope, including making drawings, preparing tissues, cutting sections, staining, mounting, and injecting.

The second part is arranged under forty-nine separate headings, commencing with blood and ending with the umbilical cord. Each subject is dealt with under distinct sections, "preparation" and "examination," the latter under high (300) and low (65) powers. The arrangement of this part of the book typographically and otherwise is exceptionally excellent. Another special feature consists in the plates, in which the main features of the chief sections are indicated in outline, it being left for the student to fill in the details, the leading parts of which are indicated in the text. The frontispiece is so filled in with colours as an example.

Dr. Klein complains † that the author has not acknowledged his indebtedness to the 'Atlas of Histology' and other books.

* Stirling, W., 'A Text-book of Practical Histology, with Outline Plates,' lvi. and 130 pp., 31 pls. and 27 figs. (4to, London, 1881.)

† 'Nature,' xxiv. (1881) p. 163.

# PROCEEDINGS OF THE SOCIETY.

Meeting of 8th June, 1881, at King's College, Strand, W.C., The President (Professor P. Martin Duncan, F.R.S.) in the Chair.

**The Minutes** of the meeting of 11th May last were read and confirmed, and were signed by the President.

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**The List of Donations** (exclusive of exchanges and reprints) received since the last meeting was submitted, and the thanks of the Society given to the donors.

| | From |
|---|---|
| Dissected Model of the Eye in papier-maché (by Auzoux), arranged so as to be taken apart, and showing successively the Sclerotic and Choroid Coats, Cornea, Retina, Iris, Pupil, Crystalline Lens, Aqueous and Vitreous Humours, Muscles, Nerves and Blood-vessels, coloured as in the natural Eye | *Mr. Crisp.* |
| Three slides of Sponge Spicules | *The President.* |
| Three stained sections of diseased Uterus, and one of Whisker of *Phoca barbata* | *Dr. B. Wills Richardson.* |

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**The President** said the meeting would be glad to know that Professor P. F. Reinsch was present. His interesting work on the vegetable forms found in the coal measures was upon the table, and was well worthy of examination.* There would be of course some dispute as to whether the specimens were all vegetable forms or not, but the observations were in any case of considerable value. He called on Professor Reinsch for a few remarks.

Professor Reinsch briefly expressed his acknowledgments for the reception given him, and made some remarks on the coal formations at which he had more particularly been working. He had prepared a collection of mounted specimens in verification of his results, one of which he proposed to present to the Society.

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**Dr. Millar** having taken the Chair,

**The President** gave a *résumé* of his paper "On some Remarkable Enlargements of the Axial Canals of Sponge Spicules, and their Causes" (see p. 557), figures in illustration being drawn upon the board.

Dr. Millar said he had examined many specimens of sponge spicules himself, but had never seen the peculiarities which had been described. He should like to ask why, if the silica was dissolved at that depth, it was attacked on the inside and not outside?

Mr. Deby said as regarded the dissolution of the silica he might mention a circumstance which he thought bore upon the question. Some time ago he had some diatoms from brackish water, consisting

* See this Journal, iii. (1880) p. 836; and *ante*, p. 700.

chiefly of two species. He had them in a little 1-oz. phial, and both were living on some algæ at the time he obtained them. At the end of a week, however, one species died, the conditions not seeming to suit it. About that time he had to go away for two months, and on his return he found that the remaining species (*Nitzschia*) had increased astonishingly. On looking at the bottom of the phial to find the others, he was surprised to discover no trace of them, they had all been dissolved, and their substance had gone to feed the *Nitzschiœ*, which went on growing for seven or eight months until there was no more silica left in the water. When they could get no more, a rather curious thing took place—they became a little bow-shaped, and then by-and-by they got more so, until at last if some persons had found them there would have been perhaps half-a-dozen new species made out of them. When they could get no more silica they died off also. He thought, therefore, that silica could be dissolved, and could become silicate of soda in sea-water by some process which they knew not at present.

Mr. Michael said it struck him as being a singular thing that almost all the borings from the outside were at right angles to the central canal. This was so marked, that it seemed to be something more than an accidental circumstance. The borings also, in almost every instance, went up to the central canal, but did not cross it. One appeared to have commenced from the inside and not to have reached the exterior, but it was still at right angles to the central canal. The enlargement did not usually commence exactly at the boring, but at some distance from it. If they were borings, he thought they must have been done under some circumstances which had not yet been traced. He should like to know if the President could explain any of these facts, particularly that some seemed to be bored from the interior, and that the enlargement was not at the boring, but at some distance from it.

The President, in regard to Dr. Millar's remarks, said that Dr. Bowerbank proved that the most soluble part of a spicule was the portion in contact with the axial canal, and that potash acted more quickly upon it in that part than at any other. At the same time, he might say that there were other specimens shown which were being dissolved and ruined from the outside as well. Mr. Deby's remarks, he thought, rather supported him; they all knew that silica was soluble, but they did not know how its solution was effected. Carter had noticed the borings, but as regarded their direction it would be found that every now and then they got one which was oblique. It seemed that they opened out into the axial canal, and the axial canal itself was invariably enlarged; the erosion seemed to take place from within directly the penetration was effected. They had very few instances of obliquity. He concurred with Mr. Carter that they did not come from within. The first thing established was the broken-down condition of the axial canal.

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Mr. Crisp said there was to have been a discussion that evening on swinging substages, the value of which Mr. Crouch disputed.

He had, however, telegraphed from Deal that he was unable to reach London in time for the meeting, and his remarks must therefore be taken as read (see p. 668).

Mr. Stephenson, in reply to the Chairman, said he concurred with Mr. Crouch in regarding swinging substages as useless incumbrances. The large apertures of the modern immersion objectives could only be utilized by immersion condensers, and for such condensers a swinging substage was unsuitable (see p. 669).

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**Dr. B. Wills Richardson's** paper, "On a Blue and Scarlet Double Stain, suitable for Nerve and many other Animal Tissues," was read (see p. 573).

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**Mr. Crisp** exhibited and explained the construction of "Gundlach's Periscopic Eye-pieces" (see p. 659), and briefly epitomized the paper of Mr. J. D. Cox on the motion of diatoms (see p. 649).

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**Dr. Savage's** note was read, asking for the experiences of the Fellows as to the changes which took place in spirit-hardened tissues, especially in the case of nervous tissues (see p. 695).

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**Mr. Crisp** referred to the insufficiency of the views put forward by Mr. J. B. Haycraft (Proc. R. Soc., xxxi. (1881) pp. 360–79) on the cause of the striation of voluntary muscular tissue.

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**Mr. E. M. Holmes** read a paper "On a new British Alga," specimens of which were exhibited.

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**Mr. Crisp** said that Mr. T. Powell would at the close of the meeting demonstrate, by means of Woodward's and Abbe's apertometers, the very large numerical aperture of his new oil-immersion objective = 1·47 N. A., the largest hitherto made.

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**Mr. Stephenson** exhibited an $\frac{1}{8}$ and a 1-inch objective made in the year 1835 by the late Andrew Ross for the Society of Arts, and presumably of the then highest standard of excellence, as they were made for presentation by the Society to Mr. Aikin, in recognition of services rendered by him in that year. Mr. Stephenson pointed out that the great interest was in the advance which had been made in the construction of objectives during the last forty-six years, as indicated in the $\frac{1}{8}$ of 1835 by Ross and the homogeneous $\frac{1}{8}$ of 1881 by Powell and Lealand, both of which were on the table that evening. Ross's $\frac{1}{8}$ of 1835 with its triple front had a numerical aperture of 0·29 only, whilst the homogeneous $\frac{1}{8}$ of Powell and Lealand had the immense aperture of 1·47—showing an increase in resolving power, as well as in light, of no less than 500 per cent. The 1 inch of Ross of the same date (1835) had a numerical aperture of 0·10 as contrasted with the not unusual aperture of 0·25 of the present day.

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Mr. Crisp described Professor Ranvier's method of fine adjustment by the eye-piece.

Mr. Ingpen thought the use of the eye-piece for the purpose suggested would have a deteriorating effect on the definition, particularly with high powers of large aperture, which were adjusted to a certain length of body.

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Dr. Maddox, in exhibiting two photomicrographs of *Pleurosigma angulatum*, magnified 3000 diameters, taken above nine or ten years since with a Wale's $\frac{1}{8}$ photographic objective and amplifier, said, "I do so, believing they may be of interest, as exhibiting markings between the dots, which I venture to suggest may correspond to the small markings between the hexagons, to which Mr. Stephenson called attention in his paper of June 5th, 1878, entitled 'Note on the Effect of *Pleurosigma angulatum* and other Test Objects by excluding the central Dioptric Beam of Light,' and to the figure given by Dr. Alfred Eichorn's mathematically calculated drawing, produced by six equidistant spectra in a circle.

"Mr. Stephenson in his paper remarks that 'such markings would possibly have escaped observation altogether had not mathematical theory pointed out that such images ought to appear.'

"Mr. Stephenson showed these markings by a large-angled oil-immersion lens, the centre stopped out at the back of the objective by a stop of black paper with marginal openings; and in the April number of the Journal of the Society, at page 359, in the article entitled 'Notes on Aperture, &c.,' by the editor, Mr. Crisp, the figure of Dr. Eichorn's drawing is repeated with the following remarks, 'The special feature was the small markings between the hexagons which had never been seen on *Angulatum*,' with the statement that 'the small markings were found actually to exist, though they were so faint that they had escaped observation until the result of the mathematical deduction had shown that they ought to be seen.'

"As these photomicrographs were produced so long back as to be some time in advance of the papers alluded to, and if, as I venture to suppose, the markings represented be the identical markings so happily shown by Mr. Stephenson, they tend to prove the value of photomicrography.

"The difficulty attendant on producing in the negative the six small interspaced markings was extreme. I took twenty-one, if not twenty-three, negatives of the same frustule mounted dry on the cover before obtaining the markings in the print as bright spots, and then only on small parts of the frustule.

"I have had the pleasure of obtaining Mr. Stephenson's opinion after seeing the photomicrographs. He thinks the markings larger than what he exhibited in the Microscope, and suggests this may be caused by being less sharp. He also doubts if they be the same, as they were produced by totally different conditions, and suggests that I may have used seven diffraction pencils. To me they appear to occupy the position given to them in the calculated figure. I regret the photographs are so considerably faded. They were unfortunately

mounted on glazed cards, which may, with imperfect washing, have now tended to lessen the intensity of the print."

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Mr. Crisp referred to a letter from a friendly critic as to the extent to which the various matters brought before the Society had to be condensed in order to include them within the compass of the meetings. Two alternatives were open, either to deal with two or three subjects at length, or to refer with more brevity to a greater number. Hitherto the Fellows had desired the latter course, but there would certainly be no objection, on that side of the table at any rate, to adopt the first alternative if the Fellows generally desired it.

Mr. Beck, speaking not only for himself but as he believed for the Fellows generally, expressed his strong preference for the mode in which the meetings were at present conducted. If there was anything new or interesting they were sure that it would be brought before them, and there could be no dispute as to the fact that for interest and variety of matter the Society was second to none in regard to its meetings.

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**The following Notes, &c., were taken as read:—**

The invention of the Binocular Microscope (see p. 693).

Conditions of Aplanatism for wide-angled pencils.

Diffraction as regards opaque objects and isolated elements.

Aperture and Professor Clausius' theory.

The action of immersion condensers in the case of apertures exceeding 1·00 N. A.

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**The following Instruments, Objects, &c., were exhibited:—**

Mr. Crisp—(1) Vérick's Mineralogical Microscope, with mechanical stage and objective "extractor" (see p. 662). (2) Vérick's Dissecting Microscope (see p. 659). (3) Gundlach's Periscopic Eye-piece (see p. 659). (4) Woodward's Apertometer (ii. (1879) p. 781). (5) Pennock's Eye-shade for the Monocular (see p. 518).

Prof. P. Martin Duncan—Sponge Spicules in illustration of his paper.

Mr. E. M. Holmes—Specimens in illustration of his paper on a new British Alga.

Mr. Ingpen—Zeiss's Camera Lucida.

Dr. Maddox—Two Photographs of *Pleurosigma angulatum.*

Mr. T. Powell—Oil-immersion objective of 1·47 N. A.

Prof. P. F. Reinsch—New vegetable structures from Coal.

Dr. B. Wills Richardson—The slides mentioned above.

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**New Fellows.**—The following were elected *Ordinary* Fellows:—Messrs. A. S. Bishopp, J. Barrow, G. F. Dowdeswell, R. L. Huzzey, M. Johnson, and R. H. Ward.

WALTER W. REEVES,
*Assist.-Secretary.*

February, April, June, August, October, and December.

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# JOURNAL

OF THE

# ROYAL MICROSCOPICAL SOCIETY;

CONTAINING ITS TRANSACTIONS AND PROCEEDINGS,

AND A SUMMARY OF CURRENT RESEARCHES RELATING TO

ZOOLOGY AND BOTANY

(principally Invertebrata and Cryptogamia),

MICROSCOPY, &c.

*Edited by*

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*One of the Secretaries of the Society*
*and a Vice-President of the Linnean Society of London;*

WITH THE ASSISTANCE OF THE PUBLICATION COMMITTEE AND

A. W. BENNETT, M.A., B.Sc., *Lecturer on Botany at St. Thomas's Hospital,*

F. JEFFREY BELL, M.A., *Professor of Comparative Anatomy in King's College,*

S. O. RIDLEY, M.A., *of the British Museum,* AND JOHN MAYALL, JUN.,

FELLOWS OF THE SOCIETY.

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(OCTOBER.)

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SUMMARY OF CURRENT RESEARCHES, &c.—*continued.*

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☞ *A special feature of the Journal is the classified Summary it contains of the work of British and Foreign Observers relating to Zoology and Botany (principally Invertebrata and Cryptogamia), Microscopy, &c., as appearing in the principal Journals, Transactions, &c., of this and other Countries.*

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THIS Journal is published bi-monthly, on the second Wednesday of the months of February, April, June, August, October, and December. It varies in size, according to convenience, but does not contain less than 8 sheets (128 pp.) with Plates and Woodcuts as required. The price to non-Fellows is 4*s.* per Number.

The Journal comprises:

(1.) The TRANSACTIONS and the PROCEEDINGS of the Society: being the Papers read and Reports of the business transacted, at the Meetings of the Society, including any observations or discussions on the subjects brought forward.

(2.) SUMMARY of CURRENT RESEARCHES relating to ZOOLOGY and BOTANY (principally Invertebrata and Cryptogamia, with the Embryology and Histology of the higher Animals and Plants), and MICROSCOPY (properly so called): being abstracts of or extracts from the more important of the articles contained in the various British and Foreign Journals, Transactions, &c., from time to time added to the Library, so far as they relate to the above subjects.

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All communications as to the Journal should be addressed to the Editor, Royal Microscopical Society, King's College, Strand, W.C.

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Mr. CHARLES BLENCOWE, of 75, Chancery Lane, W.C., is the authorized Agent and Collector for Advertising Accounts on behalf of the Society.


C. S. ad nat. del. West Newman & Co.

New Boring Annelid (Lithognatha worsleyi)

# JOURNAL

OF THE

# ROYAL MICROSCOPICAL SOCIETY.

OCTOBER 1881.


## TRANSACTIONS OF THE SOCIETY.

### XI.—*On a supposed new Boring Annelid.*


By Charles Stewart, M.R.C.S., F.L.S., Sec. R.M.S.


(*Read 11th May*, 1881.)

Plate IX.

I am indebted to the Directors of the Eastern Telegraph Extension Company for the opportunity of examining some animals obtained at the time their cable, laid off Singapore, was raised to repair some faults.

The cable when laid consisted of a central core of copper wire surrounded by guttapercha, outside this was a layer of oakum and tar, followed by iron wire, and this finally invested by another layer of oakum and tar. As long as this outermost covering remained the cable was almost free from incrusting organisms, but as soon as the iron wire was exposed by the disintegration of the oakum it became densely covered by numerous animals, such as *Serpulæ*, corals, sponges, &c. It was in these incrusted portions of the cable that the faults were always found, and were believed by the captain, Mr. Worsley, to be due to the attacks of some boring worm, with which opinion I entirely concur. The borings passed through the inner layer of oakum, and on reaching the guttapercha either passed directly inwards to the copper core, or pursued a tortuous

EXPLANATION OF PLATE IX.

Fig. 1.—*Lithognatha worslei* (natural size).
,, 2.—Head of same. The cuticle, partly detached by the action of spirit, showed the usual creases at right angles to one another, and at 45° to long axis of worm they correspond with the striæ. (× 22.)
,, 3.—Calcareous jaws of smaller worm seen from above (× 27).
,, 4.—The same, from below (× 27).
,, 5.—Two pairs of horny jaws of smaller worm (× 27).
,, 6.—Appendages of one side of a somite (× 40).
,, 7.—Extremity of one of the upper aciculi (× 330).
,, 8.—Extremity of one of the lower aciculi (× 330).

worm-like course on the surface of the guttapercha. No animals, or even fragments of animals, were found in any of the passages. The varied character of the materials traversed shows that it was by mechanical and not chemical means that the borings were effected. Amongst numerous worms brought up at the same time as the cable, was one so peculiarly fitted by the structure of its jaws to penetrate bodies of varied hardness and texture that I fancy we have found in it the chief culprit.

Should this annelid prove new to science, I propose for it the generic name of *Lithognatha worslei*, from the most remarkable feature in its structure, the possession of a pair of calcareous jaws in addition to three pairs of chitinous ones. The specific name I have given from the captain of the ship, whose care and skill in preserving the animals found has enabled me to examine some of the most important features in the structure of this creature, and to whom also is due the credit of recognizing that the faults were probably due to the boring of some annelid.

The largest of these worms was 72 mm. long, and about 4 in breadth. It was readily distinguished from the other polychætous annelids with which it was associated, by the marked shortness of the lateral appendages and somites. As most of the worms had the jaws protruded, the white shelly plates that formed one of the pairs at once attracted attention, and looked as if the creature had died in the act of swallowing a small bivalve shell.

Each inferior jaw consists of two parts continuous with one another, viz. a broad calcareous piece in front, and a process behind of a more horny character. The broad piece is roughly triangular and curved so as to present an inferior convex and superior concave surface. Its outer border is curved upwards, forming a rounded crest, which in front forms a blunt projection, whilst behind it tapers off to a point. The anterior margin is somewhat thin, and ridges on its under surface give it a toothed character. This edge terminates below in a tubercle which is in contact with that of the other jaw. From the tubercle the inner margin passes backwards to form the inner edge of the process.

On the inferior aspect the distinction between the anterior part of the jaw and its process is very marked; along this line and a corresponding one on the upper surface the cuticle is attached so that the whole of the broad portion of the jaw projects freely above the soft parts.

A point in the thickened outer border three-quarters the distance from its anterior extremity appears to have been the part first formed, as around it are regular contour lines, which run parallel to the margin of the plate, greatly adding to the resemblance it bears to the shell of a Lamellibranch. Brown pigment is deposited in the contour lines in a triangular area whose apex is at

the point of origin of the shell, and which is bounded in front by a line extending from it to the anterior internal angle, and behind extends for a short distance on the inner margin of the process.

The process is about half as long again as the broad piece. It is of a prismatic form with an edge directed downwards; its upper surface is slightly concave.

Contour lines run parallel to the margins. Its upper surface is of a fawn-colour, deepening in front where it is well-defined from the dark mark on the larger portion of the jaw. Inferiorly the brown colour is continued throughout the whole length of the process, but is darkest along the crest.

There are three pairs of horny jaws. The inferior pair are broad, their opposed margins are coarsely dentate, so that they interlock with one another.

The jaws immediately above these are sickle-shaped, broad behind; the latter part is lodged in a corresponding depression on the upper surface of the inferior pair.

These three pairs of jaws are those only which are directly concerned in boring or biting, but above them is a pair having a flattened surface imperfectly divided into four pieces.

Above the protruded jaws are two pairs of rounded fleshy masses, and behind the larger and uppermost of these a row of five tentacles, the longest being the central azygos one. The region which bears these is broad, and it is followed by a short somite, having a small pair of tentacles on its upper surface.

This latter is followed by ordinary body somites, but with parapodia lying concealed first of all below the margin, but gradually passing to their normal lateral position.

The branchiæ borne on each somite are small, and have only one secondary process at their base. The seta is slightly bent at its tip in most cases. The aciculi above the seta are very slender and are not jointed; there are usually about five in each bundle. Beneath the seta is a much larger bundle of jointed aciculi. The neuropodial cirrus is short; immediately internal to it is an oval elevation of the somite, apparently formed by a great elongation of the epidermic cells, which are here firmly adherent to the cuticle; this organ is perhaps of a sensory nature. A large opaque mass lies between it and the bundles of aciculi; it perhaps represents a nephridium.

There can be no doubt that this worm belongs to the family Eunicidæ, but I have not been able to find a description of any possessing calcareous jaws.

This feature seems to me so important as to justify a distinct genus being made for it.

# SUMMARY

OF CURRENT RESEARCHES RELATING TO

# ZOOLOGY AND BOTANY

*(principally Invertebrata and Cryptogamia),*

# MICROSCOPY, &c.,

INCLUDING ORIGINAL COMMUNICATIONS FROM FELLOWS AND OTHERS.*

## ZOOLOGY.

### A. GENERAL, including Embryology and Histology of the Vertebrata.

**Development of the Sterlet.**†—Professor W. Salensky gives a *résumé* of his Russian paper on this subject. The segmentation of the egg is on the *amphiblastula* type; the gastrula, however, is an *archigastrula.* In the endodermal origin and in the primitive formation of its mesoderm the sterlet resembles *Amphioxus*, but it differs from it in having the *chorda dorsalis* derived from the mesoderm, and not from the endoderm. There is no real difference in the mesodermal layer of these two forms, and intermediate stages between the two conditions have been observed in Elasmobranchs. So, also, the author thinks that the segmentation of the ovum presents a transitional arrangement between the bony fishes and Plagiostomes on the one hand, and the Cyclostomata and Amphibia on the other.

**Microscopical Phenomena of Muscular Contraction—Transverse striation of the smooth fibres.**‡—In 1863, M. Ch. Rouget pointed out that alternately bright and dark bands were often seen on the "smooth" muscles of invertebrates when living, presenting great analogies to true transverse striæ, and that this striation was also observable in certain cases in the bundles of smooth fibres of the human dartos, and in those of the gizzard of fowls. In the present communication he describes the results of experiments which he undertook to determine the conditions under which this striation of the smooth fibres takes place, and the mechanism of its production, and considers that he has

* The Society are not to be considered as responsible for the views of the authors of the papers referred to, nor for the manner in which those views may be expressed, the main object of this part of the Journal being to present a summary of the papers *as actually published*, so as to provide the Fellows with a guide to the additions made from time to time to the Library. Objections and corrections should therefore, for the most part, be addressed to the authors. (The Society are not intended to be denoted by the editorial "we.")

† Arch. de Biol., ii. (1881) pp. 233–78 (4 pls.).

‡ Comptes Rendus, xcii. (1881) pp. 1446–9.

established that the striation is due to the fact that in the act of contraction (when alone striation is observed) the fibre folds on itself, and so gives rise to elevations alternating with depressions, which seen in front appear as alternating dark and bright striæ, and in profile as a zigzag or sinuous curve.

The cell-fibres, observed under polarized light, are, in the smooth state, uniformly doubly refracting; when contracted, on the other hand, they exhibit, in the darkened field, an alternation of light and dark bands, or if a purple tinted plate be introduced, an alternation of purple bands with blue or yellow ones according to the orientation. When a smooth fibre is accidentally greatly folded, the same alternation of isotropic and anisotropic bands is observable.

The smooth fibres of the adductor muscle of the valves of acephalous molluscs may, under the influence of purely artificial conditions, acquire all the characters of striated fibres. Submitting the living animal to the action of steam, the muscles are killed at about 45° to 50°; their temperature continuing to rise, the smooth fibres at length contract violently at one end of the adductor, and break away from the shell. The smooth fibres at this end, dead and crisped by the heat, acquire, in consequence of this purely physical action a striation so fine and regular that it is in no way inferior to the delicate striation of the fibrils of insects' wings, and presents the same appearances as them in ordinary and polarized light.

A fibre which has lost all contractility may therefore still acquire all the peculiarities of structure and optical characters of striated fibres, if fine and regular foldings have been produced.

**Blood Stains.***—Dr. C. O. Curtman considers that after the thorough investigation of the subject of blood-stains on linen or other articles of apparel by Dr. J. J. Woodward no expert will be found to assert that he can positively identify human blood by any microscopical device, particularly after having been dried and subjected to the necessary preparation for microscopical investigation. Even if all the difficulties in the way of such an identification were successfully overcome, and the minutest distinctions could be made between the different kinds of blood, such evidence would in many cases be rendered absolutely nugatory by the doubts thrown upon the source of the blood and its manner of transfer to the stained article by the following facts:—

Having been requested to make examinations of suspected blood-stains, the thought occurred to the author that there was a possibility of the transfer of human blood by predatory insects, such as the mosquito, bed-bug, &c. Experiments showed that the crushing of such an insect will yield a stain of considerable size. Mosquitoes were then captured and kept in close confinement after imbibing their fill of human blood. At different periods they were crushed, and the blood examined in various menstrua. In all cases, up to forty-eight hours after a meal, a large proportion of human blood-corpuscles were unchanged and readily recognizable.

* Amer. Mon. Micr. Journ., i. (1880) pp. 184–6.

The size and colour of the corpuscles of mosquito blood are so different that no mistake could of course arise.

As the result of more than a hundred careful measurements he gives the following sizes:—Human blood (after imbibition by the mosquito), averages (red corpuscle), in dilute glycerine, $7 \cdot 4\,\mu$ or $\frac{1}{3200}$ inch; in 80 per cent. alcohol, $6 \cdot 9\,\mu$ or $\frac{1}{4000}$ inch. Mosquito blood averages in dilute glycerine, $1 \cdot 8\,\mu$ or $\frac{1}{14000}$ inch; in 80 per cent. alcohol, $1 \cdot 4\,\mu$ or $\frac{1}{18000}$ inch. Dr. Curtman considers therefore that another prop is thus taken from the value of circumstantial evidence derived from suspicious stains in murder cases; for even if stains should be fully identified as derived from human blood, the accused may plead that they were due to the agency of insects; and a writer * on this paper closes his account with the remark, "Verily, the criminal should dwell in the land of the mosquito."

Later experiments on bed-bugs appear to show that the imbibed human blood is destroyed far more rapidly in them than in the mosquito. In one individual, after twelve hours not a trace of the human blood-corpuscle could be detected.

**Salivary Globules.**†—Prof. Stricker, of Vienna, by examination of salivary globules under high powers (obj. No. X. of Krafft and Seibert), has obtained the following results:—He cannot accept the supposition of a so-called Brownian (molecular) movement in salivary corpuscles. He has found the globules to consist of a complete, distinctly visible network. The granules, which have been seen under low powers of the Microscope, appear on close inspection and carefully focussing to be thickened points of intersection of the threads forming the reticulum. There is a permanent fluctuation of the threads during the life of the corpuscle. By the action of concentrated salt-solutions, the fluctuation ceases gradually and the reticular arrangement disappears.

## B. INVERTEBRATA.

**Fossil Organisms in Meteorites.**‡—Dr. O. Hahn, who will be remembered for the part he took in the "Eozoon" controversy,§ claims to have established the existence of fossil organisms in sections of meteorites, and his views have been confirmed by Professor Karsten and Dr. D. F. Weinland, the former of whom recognized vegetable forms, while Dr. Hahn was only able to find animal organisms. To enable a better judgment to be formed by the preparations made by Dr. Hahn, 32 photolithographic plates are given of 142 (transparent) sections.

Dr. Weinland estimates that there are 50 various species of polypes, crinoids, and algæ in Dr. Hahn's preparations. They are united by a siliceous material, and the most interesting feature is their diminutive size, the spicula of sponges, for instance, being indistinguish-

* Louisville Med. Herald, ii. (1880) p. 323.

† 'Nature.' xxiv. (1881) p. 203.

‡ Hahn, O., 'Die Meteorite (Chondrite) und ihre Organismen,' Tubingen, 1881.

§ See this Journal, iii. (1880) p. 471.

able by the naked eye. "These celestial fossils* tell us of a planet on which aquatic life was sufficiently developed to produce them and to preserve them after death by a process of infiltration with siliceous material, which dissolved the lime of which their structure must have consisted as far as their inorganic constituents are concerned, and supplanted it by the various kinds of siliceous materials, filling up also the interstices and openings which had formerly contained organic substance. This planet, therefore, must have had a comparatively long period of existence; it must have had an atmosphere, and its surface must in whole or in part have been covered by water. . . . Since bacteria are known to be able to withstand a temperature of $-100°$ C. without losing vitality, the Thomson-Richter hypothesis of the propagation of life through the universe becomes almost a tangible reality."

Dr. Hahn recently sent microscopical sections to the Geological Society, and on his behalf the negative considerations were pointed out,† which forbid that such structures should be classed among crystalline forms:—

"The chondrites, the species of meteorites from which the specimens are prepared, consist, besides the metals which they enclose, of the minerals enstatite and olivine.

"In his work on the meteorites and their organisms, Dr. Hahn has given photographs of 130 different forms and structures. Now, if these structures are crystalline, the two minerals in question would present themselves in at least 130 different forms and structures, although the absence of all structure is recognized as a fundamental principle of the theory of minerals. Again, the structures exhibited by the chondrites cannot be due to slaty cleavage, since olivine has no slaty cleavage, and that of enstatite and of other minerals does not appear under the Microscope, or else presents itself there under totally different forms. The greatest importance, however, is to be attached to the total absence of all polarized light exhibited by the two minerals as occurring in the meteorites. The contained forms and structures do not polarize the light at all, or only very feebly, although the same minerals, under ordinary circumstances, polarize light very strongly. The absence of all aggregate polarization is especially noticeable, as proving that these objects are not aggregates of crystals. Should we still feel inclined to regard the inclosures as mineral forms, and not as organisms, we must be struck by the utter absence of all crystalline forms, especially in those very minerals which always, and occasionally also in meteorites, appear in a crystallized form.

"Further, the external forms, and consequently the outlines of the inclosures, harmonize so perfectly with their internal form and structure, that we cannot entertain the idea that these inclosures have been rolled about and ground down before they became finally imbedded in the chondrites.

"The idea of an aggregate of crystals, if still looked upon with

* See article by G. W. Rachel, 'Science,' ii. (1881) pp. 275–7.

† Quart. Journ. Geol. Soc., xxxvii. (1881) Proc. p. 7.

favour, would be contradicted by the fact that the enclosed balls or globes are all constructed excentrically, whereas all terrestrial crystallites are formed concentrically."

### Mollusca.

**American Cephalopoda.***—Professor A. E. Verrill, in addition to a list of the species collected during the season of 1880, describes some new forms. The genus *Mastigoteuthis* is the representative of a new family, *Mastigoteuthidæ*, in which the eyelids are simple, the pen narrow anteriorly and having a long tubular cone connected with its much wider posterior end; the arms are very unequal, the ventral much the longest; the suckers are small and in two regular rows; the tentacular arms have no distinct club. The species is called *M. Agassizii*. *Eledone verrucosa* is a new species, the characters of which "illustrate well the uselessness of the attempts to divide the species of *Octopus* and allied genera into groups or sections according to the relative lengths of the arms; for in this and many other cases the proportions of the arms of the right side would throw it into one section, those of the left side into another. The male would have to be put in a third section." The writer gives also a notice of his lately formed genera: *Cheloteuthis* (*C. rapax*), *Calliteuthis* (*C. reversa*), and *Alloposus* (*A. mollis*); the last of these is distinguished by the permanent attachment of the mantle to the siphon.

**Simple Eyes of some Mollusca.†**—Dr. P. Fraisse here describes the eyes of *Patella*, *Haliotis*, and *Fissurella*. In dealing with the first of these, he states that there is no ommatophor, that the eye itself is a small vesicle 0·12 mm. in diameter, and that the epithelial cells pass directly into those of the retina. These epithelial cells differ from those of the tentacle by being somewhat shorter and in being more closely packed; the retinal cells are longest at the base of the eye. Pigment is found most largely in the cells which are opposite to the pupil. It is clear that the whole of the cellular layer which forms the eye is formed of a single layer of delicate cells, the upper part of which is occupied by black pigment. There is no true optic nerve, nor is there any lens or vitreous body, or any real indications of these. Knowing these facts, we cannot be astonished at learning that in one and the same animal one eye may be, for it, well developed, while the other is much smaller and much less deeply pigmented. So far as the author has been able to make out he finds that the eyes of Molluscs commence to be formed by an invagination of the epidermis, which is at first open to the exterior; as it becomes shut off, the retinal cells become developed out of the epidermal cells, but the eye of *Patella* remains at an embryonic stage, as compared with most of the Mollusca.

In *Haliotis* the eyes are large, and are placed on retractile ommatophors, and as in *Patella*, there is an open cup. The cavity is largely occupied by a vitreous body. The cylindrical cells of the epidermis pass directly into the elongated cells, and the pigment is

* Bull. Mus. Comp. Zool., viii. (1881) pp. 99–116 (8 pls.).
† Zeitschr. f. wiss. Zool., xxxv. (1881) pp. 461–78 (2 pls.).

only found around the orifice of the cup; the retina is almost diagrammatically simple in construction. There is a lens, which is formed of a gelatinous substance. On treatment with reagents (chromic acid), it breaks up into radially arranged fibres. The characters of the optic nerve are somewhat remarkable, for it breaks up into two or three branches before entering the eye; the nerve-branches then broaden out in such a way as to enclose the whole eye and to come into direct connection with the retinal cells. In the peripheral portion of the optic nerve it is only possible to make out a large number of small ganglionic cells, but in the enlargements which surround the bulb there are cells which are three times as large as these. The eye is placed in a mass of loose connective tissue, and there is no indication of a sclerotic or of any other investing membranes.

The eye of *Fissurella* affords, according to Dr. Fraisse, an example of how very different in structure the same parts may be in closely allied animals. The eye of *F. graeca* lies just below the epidermis, the corneal being separated from the epithelial cells by a delicate layer of connective tissue. As a rule the eye is well rounded; though there is not here the same close connection as in the two previous cases between the epidermal and retinal cells, there is no doubt that the latter are derived from the former. These retinal cells belong to two groups; they may be long and very delicate at their lower ends, or they may be broader and thicker and more coarsely granulated, and the latter are, moreover, devoid of pigment. These thicker basal cells are regarded by the author, not as supporting-cells of the true retinal elements, but as those organs from which the lens and vitreous body are developed; the pigmented cells alone function as the end-organs of the optic nerve.

In conclusion, the author points out that if we compare the above described sensory organs with one another and with those of other animals, we shall find that the eye of *Patella* presents the very simplest condition, giving an indication of the phylogeny of the eye. The nearest ally of *Patella* is *Chiton*, which in its adult, though not in its young stage, is eyeless. In *Nautilus* the eye is likewise open to the exterior, and in the Hirudinea we may find organs of a somewhat similar construction. In cases of this kind the use of the term *retina* should be avoided, and be replaced by that of *rod-cells*. The cells which appear to be the organs for the perception of light are very characteristically developed in the Mollusca; what is here seen almost in diagram is found more or less distinctly in all other Molluscs. The so-called retina consists of a series of elongated cells, the anterior portion of which is filled up by dark pigment. This pigment is more or less marginal in position, so that there is in the centre an unpigmented cylindrical canal which passes directly into the unpigmented part of the cell.

Finally, it is suggested that a comparison should be instituted between these bodies and the rods in the eyes of the Arthropoda.

## Molluscoida.

**"Olfactory Tubercle" of Simple Ascidians.***—In this paper Dr. W. A. Herdmann investigates the value of this organ "as a specific character"; but he points out that in retaining the name he recognizes the importance of Julin's recent investigations as throwing "grave doubts on the supposed sensory function of this organ." He describes its position on the branchial sac and its relations to neighbouring parts; to the wedge-shaped space between the two peripharyngeal bands which bound the *zona prœbranchialis* he gives the name of "peri-tubercular area." He says that when a little complicated, "the curves into which the band of the tubercles may be twisted and the resulting shapes of the organ seem infinite." There is no doubt that the characters vary according to the family, genus, and species; but Dr. Herdmann finds that it is subject also to great individual variations in some species. To test this matter further, eight common species were carefully examined, and the range of variation, which again differs in different species, was studied by the aid of a large series of specimens.

**Organization of the Simple Ascidians.†**—In his previous contribution,‡ M. Charles Julin refrained from giving an opinion as to the functions of the hypophysis; further studies lead him to think that the question can now be well answered in the terms of Professor van Beneden's report to the Belgian Academy of Sciences: "It is probable that the products of the hypophysis of *Phallusia mammillata* are excretory products. Physiologically, then, the organ would be a kidney. If this is the case with *P. mammillata*, it is very probable that it is the same also in the case of other Tunicates." When we examine the structure of the gland, we find that, unlike most glands, there is more than one excretory orifice; 128 ciliated infundibula were found completely developed in one not adult individual. These funnels have been found to be formed at the expense of the blind ends of the canals, and to come into connection with the exterior by the absorption of the peribranchial epithelium.

The hypophysial apparatus of the adult *Phallusia* is described as having the following structure. It is 31 mm. long and has a principal canal, the calibre of which varies considerably at different points. The principal infundibulum is strongly pigmented and opens by a circular orifice into the buccal cavity; the glandular mass itself is only $1\frac{3}{4}$ mm. long. There are secondary canals and infundibula; the glandular mass is seen to diminish, while the system of secondary canals increases as the animal grows older. The principal canal gives off a number of secondary branches, which again ramify; these ramifications unite, and give rise to a plexus on the dorsal face of the animal; the calibre of the different canals varies considerably, but they all have their walls formed of a cubical epithelium. As compared with the earlier stages, the

* Proc. R. Phys. Soc. Edin. (1881) 14 pp.
† Arch. de Biol., ii. (1881) pp. 211–32 (1 pl.).
‡ See this Journal, *ante*, p. 590.

number of secondary infundibula will be found to have greatly increased, more than 500 being now present. The author points out that the presence of more than one excretory orifice obtains in the Cestoda and Trematoda, and that if the observations of Hatschek are correct, *Polygordius* commences with a renal organ which has a single orifice, and only secondarily gets a series of orifices. If M. Julin's studies are corroborated, we shall have in the hypophysial gland of the Tunicata the primitive renal organ of the Chordata.

**Cœlom of the Ascidians.*** — Professor E. van Beneden states that the mesoderm of the larva is formed by two lateral plates, which are formed solely in the posterior half of the embryo and at the expense of the endoderm; the hinder half of each gives rise to the muscle-cells of the tail; the anterior encloses a cavity which seems to be a lateral diverticulum of the archenteron, or, in other words, an *enterocœle*. The cells of the anterior half of the mesodermal plates become rounded, separate from one another, and take on the character of blood-corpuscles.

In the adult *Perophora* the heart is formed by a single layer of cells, the deeper parts of which have their protoplasm transformed into muscular fibrillæ. The generative organs and their ducts are developed at the expense of a small mass of mesodermic cells, in which there appears an excentric cavity which by growth gives rise to a sexual vesicle; this divides into two lobes, of which the outer one forms the female and the inner the male organs. The author finds a very close analogy between the development of the pericardium and that of the sexual vesicle. "If the pericardiac cavity is the homologue of that of Vertebrates, the cavity of the sexual organs is the homologue of the abdominal cavity. They both have the characters of a true cœlom," and the mouths of the efferent ducts appear to represent abdominal pores. The enterocœle of the larva disappears completely, and the bounding epithelial cells give rise to a true mesenchyma.

Professor van Beneden has noticed that the muscles of the Ascidians, and even the mode of the termination of the nerves in the muscle, resemble the smooth fibres of the Vertebrata.

**Metamorphosis of Pedicellina.**†—M. J. Barrois finds that this Polyzoon becomes fixed by the oral, and not by the aboral, pole of its body. The digestive tube is rotated from before backwards, when the intestine ceases to have a horizontal position and passes through two stages. In the first, which is analogous to what is seen in *Loxosoma*, the enteron is vertical, and its orifices look towards the posterior surface of the larva; in the second the enteron is horizontal, and its orifices are directed upwards. The vestibule meantime becomes divided into three distinct parts; the lowest contains elements which go to form the foot-gland; the uppermost forms the tentacular chamber, and comes into connection with the exterior by means of an invagination of the ectoderm; the median portion undergoes degenera-

* Zool. Anzeig., iv. (1881) pp. 375–8.
† Comptes Rendus, xcii. (1881) pp. 1527–8.

tion and gives rise to a mass of globules, which finally give rise to the so-called colonial nervous system. The "enigmatic" ectodermal organs are regarded by the author as temporary parts, which take up a dorsal position, and gradually disappear.

## Arthropoda.

### a. Insecta.

**Blood of Insects.***—After alluding to the functions performed by hæmoglobin in the blood of Vertebrates and many Annelides, by chlorocruorin in that of other Annelides, and by hæmocyanin in that of many Molluscs and the Crustacea, M. L. Frédéricq gives an account of some experiments on the larva of *Oryctes nasicornis*, undertaken with the view of ascertaining whether the same alternating phenomena of combination and dissociation, of coloration and decoloration of the blood existed in the case of insects.

A small incision was made with a pair of fine scissors through the skin of the back and the walls of the dorsal vessel, into which was inserted with care a slender glass cannula. The blood immediately rose in the tube. It is a colourless fluid, presenting nearly the aspect of mammalian lymph, holding in suspension a large number of colourless globules which slightly affected its transparency. It immediately collects in lumps and coagulates spontaneously This coagulation is not stopped by the addition of NaCl., $MgSO_4$, &c.; but a slight rise in temperature (not reaching 55°) is sufficient to prevent it.

When exposed to the air this colourless fluid soon becomes of a dark brown colour, especially well defined around the masses of globules. Light plays no part in this change of tint, which is due to oxidization. The blood boiled with a little water and completely coagulated still turns brown on exposure to the air; but that which has been coagulated by alcohol appears to have lost this property.

The brown fluid, when examined by the spectroscope, shows no characteristic absorption band. At first sight it would appear as if the blood contained a substance similar to hæmoglobin or hæmocyanin, but this view cannot be supported.

A clear proof that the coloration plays no part in the respiration of the animal, is, that the brown substance, once formed, constitutes an extremely stable combination which is not decomposed either by acids or by alkalies, and which is not deprived of its colour when placed *in vacuo* or preserved in a closed vessel.

The author, therefore, considers that the phenomenon of coloration afforded by the blood when exposed to the air is one of death, comparable to spontaneous coagulation. The substance which thus turns brown in air does not serve as a vehicle between the outer air and the tissues that require it. The existence of such an intermediary is extremely problematical having regard to the anatomical disposition of the respiratory apparatus of insects where the surrounding air penetrates by the system of tracheæ to the very centre of the living tissues.

* Bull. Acad. R. Sci. Belg., i. (1881) pp. 487–90.

**Structure of the Stigmata of Insects.***—Dr. O. Krancher, who has already published a preliminary account of his investigations,† here enters into a very elaborate description. After some historical remarks he proceeds to a general account of the organs in question, of the substance of which we have already given an abstract. He then gives a list of the forms he has examined and enters into a detailed description of their peculiarities. As a general result he finds that the variation both in the structure and form of the stigmata is unexpectedly large. No systematic generalizations can be drawn from the study of these, but, in proportion as their value diminishes, the greater importance do we give to the influence of adaptation on their structure.

The following has been the author's method of investigation—when he had only to do with the connection between the several chitinous parts, the portions to be examined were treated with a 10 per cent. solution of potash, the water was then removed by alcohol, the object clarified by oil of cloves and set up in Canada balsam. When the muscle was sought for, the whole object was first coloured by a solution of picrocarmine. Sections were also made after imbedding in paraffin; soap was found to be of no use as an imbedding material.

**Origin of the Tracheal System of Insects.**‡—Dr. H. A. Hagen is unable to agree to some of the views of Dr. Palmén on this subject, and is himself of opinion that the so-called stigmatic cords are not rudimentary and closed tubes, but useless open ones; he points out that in *Æschna*, for example, the tracheal system is not closed, and he reminds his readers of the experiment of Lyonet, who, by placing a larva in water, and then heating the water, found that air-bubbles escaped from it. Dr. Hagen has, with satisfactory results, repeated this experiment. This would seem to strike at the root of Dr. Palmén's principal position, that the stigmatic cords do not become completely developed during the larval stages.

**Endocranium and Maxillary Suspensorium of the Bee.**§—Professor G. Macloskie has published a paper in which the anatomy of these parts of the honey-bee is very fully and elaborately dealt with, comparing them with their representatives in a few other insects. The paper itself must be referred to as it is not capable of being usefully abstracted.

The author complains that "anatomists have not paid much attention to this class of structures, and some eminent students of insect embryology are as silent regarding the endoskeleton as if they had never heard of such parts, although all efforts to evolve an insect's embryology ought to include as a preliminary study the structure of its internal economy."

He considers as the result of his observations that they indicate a

* Zeitschr. f. wiss. Zool., xxxv. (1881) pp. 505–74 (2 pls.).
† See this Journal, *ante*, p. 34.
‡ Zool. Anzeig., iv. (1881) pp. 404–6.
§ Amer. Natural., xv. (1881) pp. 353–62 (6 figs.).

fundamental unity of structure of the heads of all insects, but how far and in what directions it is varied, and what is its relation to other parts of the body are questions needing further research.

**Aquatic Larvæ of Lepidoptera.***—M. C. Maurice points out that, strange as it may seem, aquatic caterpillars are to be found in nearly every group of the Lepidoptera. He describes the presence in *Paraponyx stratiotata* of a system of tracheal gills, in which the delicate membranes provide for the animal's respiration an endosmosis of oxygen and an exosmosis of carbonic acid. Stigmata are, moreover, to be found in the thoracic regions of these forms, but they are not functionally active during the larval stage as they are closed by a delicate membrane, and they do not become useful till the marsh in which these larvæ live becomes dried up. The author is unable to decide the question whether *Paraponyx* is a degraded form, or whether it does not indicate a connection between the *Lepidoptera* and the lower orders of insects.

Attention is finally drawn to the proofs lately given that aquatic larvæ are to be found in the families of the Bombyces and Sphingidæ, but it is pointed out that in neither of these cases is there as yet any evidence as to the presence of tracheal gills.

**Relation of Devonian Insects to Later and Existing Types.**—In 1862 the fragments of six insects were discovered in the Devonian strata of New Brunswick and were considered to be the oldest known fossil insects. They form the subject of an elaborate memoir,† by Mr. S. H. Scudder (having been preceded by other communications), of which the most important conclusions were given *ante*, p. 236.

Dr. H. A. Hagen,‡ however, arrives at conclusions radically different from those of Mr. Scudder, and in particular he states that (1) the fragments belong to five species of Odonata and Neuroptera; (2) none of them have any relation to the Ephemeridæ; (3) none are of a synthetic type; (4) the previous stages of all were probably aquatic; (5) no related species is known from the North American Carboniferous strata — probably all insects known from them are terrestrial; (6) the four families proposed by Mr. Scudder are based upon extremely vague characters, not properly family characters.

### γ. Arachnida.

**Pycnogonida of the "Blake" Expedition.§**—Mr. E. B. Wilson reports upon this collection of ten species dredged in 1880 off the eastern coast of the United States at a depth of 73–1242 fathoms by Prof. A. Agassiz. The most striking feature is the remarkable size of most of the forms, which may fairly be called colossal in comparison with shallow-water or littoral species. Of the three species of *Colossendeis* (two apparently new), the smallest has a span of 14 cm. between the tips of its outstretched legs, while the largest has

* Bull. Sci. Dép. Nord, iv. (1881) pp. 115–20.
† Anniversary Mem. Bost. Soc. Nat. Hist., 1880, 41 pp. (1 pl.).
‡ Bull. Mus. Comp. Zool., viii. (1881) pp. 275–84.
§ Ibid., pp. 239–56 (5 pls.).

an extent four times as great. The first new genus *Scæorhynchus* (1 sp.) has an extent of more than 19 cm., a gigantic size as compared with the dimensions of its nearest allies. The most abundant species of *Nymphon* is the largest of that extensive genus; and one of the two new species of the other new genus *Pallenopsis* is more than twice as large as any of the species of allied genera (*Pallene*, *Phoxichilidium*, *Anoplodactylus*), which are known only from the littoral zone or comparatively shallow water.

It is, further, interesting to note that in a number of forms the visual organs (ocelli) are rudimentary and destitute of pigment (*Colossendeis colossea*, *C. macerrima*, *Scæorhynchus*) or entirely absent (*Colossendeis angusta*). On the other hand, in *Pallenopsis* the ocelli are relatively of unusually great size. All the other species are known to occur also in shallower water, and the ocelli are of the ordinary form.

*Scæorhynchus* and *Colossendeis* are of especial interest as showing clearly from anatomical evidence the complete independence of the accessory legs and first pair of ambulatory legs, which has been already proved by Dohrn from embryological data. The accessory legs have been something of a stumbling-block to those who would trace the Arachnid affinities of the Pycnogonida by a direct homology of their appendages, and in the view of the author it is impossible to homologize the Pycnogonid appendages with those of the Arachnida unless a segment of the latter has been suppressed somewhere between the cheliceræ and ambulatory legs. The possibility of such a suppression is shown by the fact that in a number of Pycnogonida the process has taken place, and without leaving a trace in the embryological record. Thus in *Pallene* the palpi are wholly wanting, both in the adult and in the larva. Granting that such a suppression may have taken place, the homology of the Pycnogonid and Arachnid appendages is manifest. This suggestion must, however, be taken for what it is worth, for it is easily possible that the external resemblances of a Pycnogonid to an Arachnid are those of analogy only, and have no morphological significance. This is the more probable from the extreme variability of the three anterior pairs of appendages in position and structure.

One more point of interest may be noted. In *Scæorhynchus* the anterior pair of appendages (cheliceræ or "antennæ") present very decided sexual differences. This has not before been observed in the Pycnogonida, and furnishes another illustration of the surprising modifications which the anterior pairs of appendages undergo in this group.

**Hydrachnida of the Lake of Geneva.***—F. Könike here gives a revision of the nineteen Hydrachnida described by Lebert. The author cannot agree with Lebert in regarding the epimera as foot-joints, but takes the view of Claparède, who did not consider them to be part of the feet. So, again, the palpi are not six- but five-jointed, for the basal joint of Lebert is regarded as a part of the

* Zeitschr. f. wiss. Zool., xxxv. (1881) pp. 613–29 (1 fig.).

so-called labium. It is pointed out that the difference in the number of eyes, two or four, is due to some describers not having noticed that the four eyes are in some cases so closely approximated as to appear to be two.

**Revival of Tardigrades after Desiccation.***—The truth of the occurrence of this phenomenon has been denied by various observers, and the appearances explained by Ehrenberg as due to development of fresh specimens from eggs left by the animals, which die in the process. Professor Jung, however, considers that his observation of the process in a single specimen of *Milnesium* proves the correctness of the old opinion. The specimen was taken from a ditch, contained eighteen eggs, and manifested lively movements. It was left for five hours until quite dry, and all that could then be seen of it under 350 diam. was a brown speck under the cover-glass. A drop of water was allowed to run beneath the latter. Almost immediately after it had reached the remains of the Tardigrade a fine pellicle was evident, surrounding the brown speck and manifesting the general outlines of the body and ova. The normal wall then appeared, enclosing the contents of the intestine; the minutest details of the outer skin appeared; after twenty minutes the mouth with its fringes and tube, the jaws, and the feet were fully developed. Subsequently the parts connecting the jaws with the œsophagus came into view. No movements and no development of the ova were observed in the three hours occupied by these observations. The too close apposition of the cover-glass to the slide being now remedied, the animal was supplied plentifully with water, but, when searched for the next day, could not be found, having probably departed in search of more comfortable quarters, for the algæ which had surrounded it were disturbed, and neither the remains of the jaws and skin usually found after specimens have died, nor the eggs, were discovered.

### δ. Crustacea.

**Circulatory Apparatus of Marine Hedriophthalmata.**†—In this elaborate essay M. Yves Delage first deals with the Isopoda and Amphipoda, between the circulatory organs of which there is, he says, at first no great resemblance. In the latter we see the greatest simplicity, arterial ramifications are rare or absent, the blood-cavities are large, the venous and arterial systems are not discrete; in the Isopods there is great complexity of arrangement, arterial ramifications without number, the blood-cavities are narrow or distinctly limited, and the venous and arterial systems are perfectly distinct. Notwithstanding these differences the author thinks that the one set may be shown to have a fundamental resemblance to the other, and to be but a more perfected apparatus.

Dealing with the primary objection that the heart of the Amphipod is thoracic, and that of the Isopod is abdominal in position,

* Zeitsch. Gesammt. Naturw. (Giebel) vi. (1881) pp. 190–2.
† Arch. Zool. Expér. et Gén., ix. (1881) pp. 1–173 (12 pls.).

M. Delage points to the existence of a series of intermediate forms, and "moreover, and this is the important fact, the heart ought to be considered as a portion of a long dorsal vessel, which has become contractile at one point. The fact that that point is found in the superior, median, or inferior portion of the vessel is, then, an altogether secondary fact." Next, the origin of the pericardium by the fusion of pericardiac lacunæ is pointed out. The writer explains the difference in the mode of termination of the hearts of these groups, the Isopods having below a cul-de-sac, while the Amphipods have the inferior extremity continued into an azygos inferior aorta, by urging that the fact of the inferior aorta of the Isopoda arising on the anterior face of the heart authorizes us in considering all that portion of the heart below this point as a kind of cul-de-sac, a physiological aneurism developed on the dorsal face. The important differences in the two systems appear to be two: (1) the presence or absence of afferent arteries for the limbs, and (2) the opposite direction taken by the blood current in one as compared with the other. The author, however, believes that the second difference is a result of the first, and that would appear to be due to the special development of part of the centripetal venous system, and by the further development of special vessels out of the ventral sinus.

After dealing briefly with the Lœmodipoda M. Delage passes to the *Tanaida*, which he regards as distinct from the rest of the Isopoda; he points out the characters in which they resemble other groups, and gives a kind of phylogenetic diagram in which they occupy the base of a stem which diverges not only into the three divisions of the *Hedriophthalmata*, but also bears the *Podophthalmata*; and the paper concludes with a catalogue of all the species of these two divisions which have been found at Roscoff.

**Studies on the Bopyridæ.***—Professor R. Kossmann describes the genus *Gigantione* from the Mauritius, and *Bopyrina* from Naples, and enters into a full account, critical and descriptive, of the characters of these two forms.

**Characters of the Copepoda.**†—In this essay Professor Claus especially deals with the Copepods of the Bay of Trieste. In the first half he deals with some anatomical points. He points out that in the heart the lateral clefts always belong to the hinder half and lie in the second thoracic segment; the cardiac tube is attached to the dorsal integument and to the neighbouring organs by suspensory pieces of connective tissue, which either form separate fibrous bands or compound broader plates; they aid in bounding off the large blood-sinus. The arrangements appear to be simplest in *Cetochilus*, in which genus the anterior aorta is replaced by a wide blood-lacuna; the heart of *C. septentrionalis* is mentioned as a peculiarly good object for investigation. The unusually long cardiac tube has an upper and a lower suspensory ligament, and other attaching fibres, the arrange-

* Zeitschr. f. wiss. Zool., xxxv. (1881) pp. 652–80 (2 pls.).
† Claus' Arbeiten, iii. (1881) pp. 313–32 (3 pls.).

ment of which is carefully described. There are a pair of muscles arising just behind the cephalic region, which are of especial importance in the action of the heart. In a fresh living form the cardiac pulsations may be seen to be extraordinarily rapid, and when they become slower, the valve of the muscles is very clearly seen. The general structure of the heart of *Cetochilus* is repeated in other Calanidæ, but in *Calanella* there is an aorta of extraordinary length; the heart of *Ichthyophorba* and *Temora* is greatly widened in its posterior half. The heart appears to be defended by two tactile setæ, which arise from the sides of the second thoracic segment, and which may be seen to be provided with nerves given off from a ganglionic cell. In addition to these, there are in the succeeding segments paired tactile setæ, which are larger in the male than in the female.

In dealing with the unicellular tegumentary glands, the author states that he is able to confirm the account of Professor Haeckel with regard to *Sapphirina* and *Sapphirinella*, which was of great interest, as from it we first learnt of the innervation of these glands. As a rule a single, more or less pyriform, glandular cell is found at the hinder end of the furca, and this opens to the exterior by a large pore. In some forms this pore is surrounded by a chitinous ring. The gland generally contains clear vesicles which run together and pass out from the pore as a drop. In *Temora* there is a second glandular cell, placed in the last abdominal segment; a nucleus to the cell can rarely be observed. The furcal glands are developed in the metanauplius stage. A large number of flask-shaped glands are frequently developed in the cephalothorax and in the thoracic segments; if we take as an example *Temora* we find them to be pyriform and to have more or less highly refractive contents, with a large and distinct pore. These glands, which may also be developed on the appendages, seem to aid in the preservation of the species.

Others, which are found on the genital segment of the female, appear to have a different function, for they would seem to furnish a secretion by which the spermatophore of the male is attached to the body of the female. They are largely developed on the two anterior abdominal segments of *Ichthyophorba denticornis*, where they call to mind the clitellum of the Oligochæta, although, of course, they are not completely continued over the whole of the dorsal surface.

In the second, or systematic, portion of his paper, Professor Claus describes a new genus, *Eucalanus* (for *Calanus mastigophorus*), and gives an account of some species already known to science, together with some remarks on genera insufficiently characterized.

**Development of Cetochilus.***—Dr. C. Grobben has selected *C. septentrionalis* for the study of Copepod-development. Numerous studies have already been made of the free-living forms, and Claus' well-known work deals exhaustively with the external form and with the characters of the appendages. The egg of the form selected offers peculiar advantages for the study of the earlier stages, as it is transparent, is of some size, and each egg is laid separately.

* Claus' Arbeiten, iii. (1881) pp. 243–82 (4 pls.).

*C. septentrionalis* is an exception to the rule that the female Copepods continue to carry their eggs till the *Nauplius*-stage is reached; the eggs are laid in the water, just as in the case of *Dias longiremis* and some other Calanidæ. When laid, the egg is spherical, its yolk consists of a granular protoplasm, in which are found albuminous bodies; at first there is no polar differentiation. The author enters into an account of the characters of the investing membrane; and proceeds from this to a history of the ovarian nucleus, and to note the presence of but a single sperm-nucleus. Cleavage is complete, and there early appears a small spindle-shaped cleavage cavity in the centre of the egg. When 32 blastomeres have been developed there is a large central cell, which is distinguished by its rich supply of yolk-spheres, and its coarsely granular protoplasm. This is the "central endodermal cell;" other endodermal cells are the single anterior and the four lateral cells. In the hinder region mesodermal elements are already apparent. There is a considerable pause after the 32-cell stage, during which the blastomeres appear to absorb yolk-material. Two primitive mesoderm-cells are to be seen at a later period, which, by dividing, give rise to four, in very much the same manner as that already observed by Rabl in the Molluscan *Planorbis*.

The endodermal invagination takes place thus: the eight lateral endodermal cells sink inwards, they are followed by the four central and by the uprising of part of the ectoderm to give rise to two ridges at the sides of the blastopore. The four mesodermal cells now lie between the ectoderm and the invaginated endoderm; and the ectodermal cells undergo further division. This is followed by the closing of the blastopore, the characteristics of which are pointed out and explained. Only two stages could be observed between this point in development and the appearance of the *Nauplius*, which, when complete, has an oval form, the first antenna uniramose, the second and the mandible biramose; the œsophagus is short, the mid-gut straight, but the rectum and anus are not yet present and are only represented by an ectodermal elevation. There is a supra-œsophageal ganglion, and a faintly reddish pigment-spot; the sub-œsophageal ganglion belongs to the mandibular segment; all the parts of the nervous system are still in connection with the integument.

In its further development the *Nauplius* undergoes a number of ecdyses, in the course of which the body elongates, and the hinder end becomes provided with a number of hooks; these are described in some detail.

The author is led to some general conclusions which may here be shortly summarized. He thinks that probably the ejection of the "directive corpuscles" is not a rare phenomenon among the Crustacea; but it does not seem to obtain in those forms which exhibit parthenogenesis. He believes that, notwithstanding some appearances to the contrary, cleavage is really bilaterally symmetrical; the development of the mesoderm from two cells appears to be very common among the Entomostraca. In addition to the significant pause in development already mentioned, another occurs at the time

when all the organs of the *Nauplius* are present in rudiment. Both these pauses appear to be due to the want of further nutrient matter.

One of the most important phenomena in the later development of the larva is the development of the generative organs, the rudiments of which appear very early. Here we have an example of the development of the generative organs from the primitive mesodermal cells; the cause of this early differentiation is, in the author's opinion, to be found partly in the phenomenon of parthenogenesis. The organs which are unpaired in the adult are, in the rudimentary stage, paired, and this shows that the paired stage is, contrary to the opinion of Gegenbaur, the earlier condition. So again, the organs are primitively ventral in position, although in the adult they are dorsal; and this it is interesting to compare with the permanently ventral position of the ovary in *Peripatus* and the Myriopoda. The large lateral compound eye of the Phyllopoda is degenerate in the Copepoda, and the secondary portion of the cerebrum comes into connection with the primary part of the growth of this latter, and by the formation of new parts from the neighbouring ectoderm.

**Organization of Trilobites.***—Mr. C. D. Walcott here gives a most interesting account of the results of a seven years' investigation.

It will be remembered that in 1873 Prof. L. Agassiz brought forward what he believed to be ample evidence of the presence of crustacean legs in an *Asaphus platycephalus*. After a historical review of the opinions on the matter the author gives his own account of the structure of the Trilobite. Beneath the dorsal shell we find (1) the ventral membrane, (2) the intestinal canal, (3) the appendages beneath the head, (4) the appendages of the thorax and pygidium, and (5) the respiratory apparatus. The first of these was thin and delicate, and was strengthened in each segment by a transverse arch, to which the appendages were attached. The intestinal canal is but rarely seen; if one specimen in a hundred shows it we have a "large proportion." The visceral cavity was usually filled with calc spar, and all vestiges of the canal or any other organ obliterated. The most interesting point is that the appendages of the body are found to differ slightly in the genera *Calymene* and *Ceraurus*. Of the latter genus the author gives an illustration which is the finest of the Trilobites "as yet known." It would seem to be certain that there is a "series of jointed legs extending from the cephalic shield beneath the thorax and pygidium to the posterior segment of the latter; that, as far as known, they were ambulatory, and formed of six or seven joints; that to the basal joint there were attached an epipodite and branchia; and that, from the proof we now have, there is little doubt but that the appendages beneath the pygidium did not vary essentially from those of the thoracic region." The branchial appendages consist of two series, attached as branchiæ to the basal joints of the legs, and as branchial arms or epipodites. The former appear under three forms; the epipodite was formed

* Bull. Mus. Comp. Zool., viii. (1881) pp. 191–224 (6 pls.).

of two or more joints, and appears to have had the function of producing a current of water among the branchiæ.

In the following table the author gives expression to his views of the affinities of the Trilobites. Placing after the Crustacea and before the Arachnida the class *Pœcilopoda*, he thus arranges the latter:—

| | |
|---|---|
| Sub-class *Merostomata.* | Sub-class *Palæadæ.* |
| Order *Xiphosura.* | Order *Trilobita.* |
| „ *Eurypterida.* | |

A succeeding table gives the characters of the different orders. As to the order Trilobita, he finds that, while it agrees with the others in such points as the structure of the cephalic appendages, it differs from them in the thoracico-abdominal regions having appendages to all the segments and the abdominal segments anchylosed, but he is careful to point out that his work has been palæontological.

A note on the ova of the Trilobite concludes the discussion of this subject. In a critical note * "J. D. D." points out that if the legs were so distinct as Mr. Walcott represents them "it seems to be incomprehensible that such dissections should have been needed for their discovery. A series of distinct ambulatory legs on a large Trilobite should have been large and stout;" and it is suggested that the parts in question are "merely subdivided and thickened portions of the outer ventral shell, which served as attachments for thin membranous articulated appendages such as have hitherto been attributed to Trilobites."

## Vermes.

**New Annelids from the North Sea.**†—Herr G. A. Hansen describes as new: *Polynoe assimilis*, *P. spinulosa*, *P. foraminifera*, and *P. glaberrima*; *Phyllodoce arctica*, *Brada granulosa*, *Trophonia arctica*, *T. borealis*, *T. rugosa*. Fifty-five species altogether are catalogued in this addition to our knowledge of the distribution of these forms; they were all collected during the Norwegian expedition of 1878.

**New Lumbricina.**‡—Dr. L. Oerley describes two new forms of the genus *Allolobophora*—*A. Fraissei* and *A. mediterranea*—from the Balearic Islands; especial attention is directed to the accessory organs of generation. It has been observed that in the adult the "tubercula pubertatis" frequently (in *A. Fraissei*) fuse with the clitellum and so become invisible; in the other new species they form delicate ridges on the twenty-eighth, twenty-ninth, and thirtieth rings. No copulatory papillæ were detected in *A. mediterranea*, and in the other species the author noticed that the setæ which Ray Lankester and Fraisse have regarded as accessory copulatory organs were not remarkably larger than the rest of the setæ. *Lumbricus terrestris*, *Enterion rubellum*, *Allolobophora fœtida*, *A. mucosa*, and

* Amer. Journ. Sci., xxii. (1881) p. 79.
† Nyt Mag. f. Naturvid., xxv. (1880) pp. 224–34 (5 pls.).
‡ Zool. Anzeig., iv. (1881) pp. 284–7.

*A. turgida* were also found in the Balearic Islands. Of some of these species Dr. Oerley has presented specimens to the Trustees of the British Museum.

**Occurrence of Corpuscles in the Red Vascular Fluid of Chætopods.** *—Messrs. J. E. Blomfield and A. G. Bourne help to overthrow the "accepted commonplace of zoological science," that the fluid in question is devoid of corpuscles. They add to the list of forms in which these corpuscles have been found *Eunice* and *Nereis*, and this they have been able to effect by treating with 1 per cent. osmic acid solution a portion of tissue well supplied by vessels, or "a portion of one of the larger vessels removed to a slide with two pairs of forceps, the blood being kept in it;" the acid was followed by picrocarmine, and the tissue treated with water and then with glycerin. They point out the necessity of a gentle pressure on the cover-slip, which causes the corpuscles to move up and down, and so distinguishes them from the nuclei of the cells of the vessels themselves. The corpuscles of *Eunice* are round and average $\frac{1}{4000}$ inch in diameter, or are oblong and have a long diameter of $\frac{1}{2000}$ inch. *Nereis* has rounded corpuscles from $\frac{1}{4000}$ to $\frac{1}{4500}$ inch in diameter.

**Thalassema neptuni.**†—Professor Ray Lankester has been enabled to study this Gephyrean in fresh specimens, collected on the south coast of Devonshire in March. The cœlomic liquid is opaque and of a very dark red colour; it contains "an immense number of perfectly smooth spherical corpuscles, each of which is deeply impregnated with hæmoglobin," and there are in addition dark masses of brown pigment. The red and brown pigments are easily separated, for fresh water dissolves the hæmoglobin. In addition to the "hæmoglobinous corpuscles," the usual amœboid bodies were also found. Hæmoglobin was further discovered in the muscles of the middle region of the body, in the thick cœlomic epithelium of the mesenterial membranes and of the genital pouches. The vascular system is essentially similar to that of *Echiurus*. By a careful system of examination the author was able to convince himself that the funnels on the surface of the cloacal pouches do open into them by a very minute pore.

Two specimens out of a hundred were found to be sexually mature, and in these the genital pouches extended over three-fourths of the length of the body, "instead of being little sausage-shaped bodies one-twelfth of the length of the worm from mouth to anus."

**Organization and Development of the Gordii.**‡—M. A. Villot here publishes in full his observations on this subject, of which preliminary notices have already appeared.§ He suppresses the order of Gordiacea formed by Von Siebold, places *Mermis* and *Sphærularia* with the Nematoids, and forms a new order *Gordii* for the genus *Gordius*, which is to take its place at the head of the class Helminthes, in the sub-class Nemathelminthes.

* Quart. Journ. Micr. Sci., xxi. (1881) pp. 500–1.
† Zool. Anzeig., iv. (1881) pp. 350–6.
‡ Ann. Sci. Nat. (Zool.), xi. (1881) Art. 3, pp. 44 (2 pls.).
§ See this Journal, iii. (1880) p. 801 and *ante*, p. 46.

He points out that the parenchyma of *Gordius* has at no time, as has been supposed, an enteric function, that the genital organs are very simple, there being two testicles or two ovaries with their ducts, a cloaca, and an "ano-genital" orifice at the posterior end of the body. The atrophy of the digestive apparatus is explained by the simple fact that the animal no longer requires nutriment, while the greater development of the nervous system at this stage is due to its free habit of life.

Monograph of the Anguillulidæ.*—Dr. L. Oerley has a *résumé* in German, in which he notices the chief results of his studies. He finds that the species which have the corium feebly developed, but a strong cuticle, are the best able to resist external agencies. The cuticle is structureless, while the corium is fibrous, and not, as Bütschli thought, multilaminate. On account of the great difficulties associated with the study of the muscular system, the author thinks that it is better not to use its characters in systematic work; this, of course, is in opposition to the well-known views of Bütschli. The efferent duct of the excretory organ is strongly chitinized, and the whole of the renal vessel is provided with an extremely fine chitinous layer. The presence of glandular tubes in the region of the mouth of *A. aceti* is distinctly denied. The author details the following experiment, to show how slight is the need for a special respiratory system. A number of *A. aceti* were placed in a vessel and covered by a layer of oil an inch thick; after two months, the greater number of these were still alive. The sensory organs of *Monhystera stagnalis* are solely represented by pigment-spots, there being no lens or any other such structure. The mouth and buccal cavity vary considerably in the different genera; in an undescribed species of *Plectus* the author has found another kind of modification of the œsophagus, by means of which the tube is divided into two elongated-oval bulbs. A glandular function is ascribed to the cellular mass which is so frequently found around the œsophagus. In *Dorylaimus stagnalis* tubules were seen passing from the mass into the œsophagus, and the author suggests that the secretion may possibly serve in the renovation of the oral spines.

In describing the *development* of *Anguillula aceti*, the writer observes that the unfertilized egg is always devoid of a membrane, which only appears after fertilization. The bilaminate condition of the embryo is certainly arrived at by a process of delamination. A clear band in the centre of the disk announces the development of the cœlom. The mouth and anus are ectodermal invaginations; the œsophagus is first indicated by a wavy line, around which the enteric cells become arranged. The whole of the genital tube (at any rate in *Diplogaster macrodon* n. sp.) is formed from the division of two terminal cells; in the male the lower terminal cell divides in the direction of its long axis, while in the female terminal cells multiply and form the ovary.

The author divides the Nematodes into three groups: (*a*) Parasita

* Termes. Füzetek, iv. (1880) pp. 1–165 (7 pls.).

for the four families—*Trichotrachelides*, *Strongylides*, *Filarides*, *Ascarides;* (*b*) Rhabditiformæ for the Rhabditidæ, and (*c*) the Anguillulidæ for the *Plectidæ*, *Dorylaimidæ*, *Monhysteridæ*, *Leptolaimidæ*, and *Tylenchidæ;* and he concludes with a description of the following new species: *Plectus de Mani*, *P. triplogaster*, *Cephalobus gracilis*, *Rhabditis heterurus*, and *Diplogaster macrodon.*

**Formation of the Cyst in Muscular Trichinosis.***—M. J. Chatin finds that when the entozoon has made its way into the muscles it soon becomes adherent to the interfascicular tissue, the connective-tissue elements of which rapidly undergo hypertrophy, and there appears an amorphous mass. In this there are to be recognized products of differentiation, such as fine protein granules, and, later on, glycogenous granulations; the appearance of which ought not, as the author thinks, to cause any surprise, as they are always to be found in very actively forming parts. Soon after their appearance considerable changes take place in the periphery of the granular mass; the new formation becomes indurated externally, and the elements form a parietal zone which becomes notably thicker. He finds that the sarcolemma takes no part in the formation of the cyst; when, indeed, the Nematoid first adheres to the sarcolemma instead of to the intermediate tissue it rapidly dies, and there is no new formation of any kind, excepting only a fibrinous exudation.

**Development of the Liver-Fluke.**†—Mr. A. P. Thomas here gives an account of his experiments on this subject, in which he was, we believe, assisted by the late Professor Rolleston. He describes the eggs of the parasite as giving a dark brown colour and sandy appearance to the bile, and in some of the smaller ducts forming a mass which completely plugs up the lumen. These eggs are oval in form, and have a yellowish-brown chitinous shell; the length varies from ·105 to ·145 mm., and the breadth from ·066 to ·09 mm. As to the number of eggs produced by a single fluke, Mr. Thomas thinks that they "may be safely estimated at several hundred thousands." In one case he obtained 7,400,000 eggs from the gall-bladder of a single sheep, in the liver of which there were about 200 flukes; this gives an average of 37,000 eggs to each; but these were found in the gall-bladder alone; "the liver must have contained as many more, and eggs had been passed copiously by the sheep for some months past."

The embryo can only develope at a temperature lower than that of the mammalian body, as was proved by experiment. But the temperature must not be too low. In the winter, for example, there is no further development. Light appears to have no influence, but moisture is an important factor. Further, it is curious and important to observe that "all the eggs under the same conditions do not produce embryos in the same time;" no explanation of this difference can yet be offered, but its importance on the question of the dangerous condition of any given field is sufficiently obvious.

* Comptes Rendus, xcii. (1881) pp. 1528–30.
† Journ. R. Agric. Soc., xvii. (1881) pp. 31.

The embryo is said to be developed by the growth of the inner cellular mass, and at the expense of the surrounding secondary yolk-spheres. After the embryo has grown so much that it occupies the whole length of the egg, a papilla appears at its anterior end, and two annular furrows and a pigment-spot become developed. Before the embryo leaves the egg it becomes provided with an investment of cilia. On escape the embryo has the form of an elongated cone, with an average length of ·125 mm. and an anterior breadth of ·027 mm. The eye-spot is said not to resemble "the sign of multiplication as has been described," but to be really double and made up of two crescentic masses of dark pigment. Midway between the extremities of the body, and on the right and left of the middle lines, are two funnel-shaped spaces provided with cilia in constant motion.

There is an appearance of probability in the supposition that the already mentioned anterior papilla has a boring function.

We now come to the important question of the fate of this embryo. We should expect to find it making its way by boring into some animal—probably a mollusc—but this has not yet been observed by Mr. Thomas, though he has no doubt as to its occurrence; nor has he been able to find the sporosac which should result from this boring in any of the Mollusca he has found on infested fields. Where, however, observation fails induction comes to our aid, and the author quotes a communication of Professor Rolleston to the 'Zool. Anzeiger' in which that lamented naturalist accuses the "black slug" or "the smaller of our two British Arions" (*A. ater* or *A. hortensis*) as being the intermediate host.

The author enters into some account of certain laboratory experiments and into a history of visits to infested pastures in the neighbourhood of Oxford; in one case only one specimen of the black slug was found, though the grey one (*A. agrestis*) was very common. Thirty specimens of this last were dissected, "but nothing could be found in them." The influence of rabbits is discussed, and the paper concludes with some practical hints on the prevention of rot, which were drawn up by Professor Rolleston and the author.

**Trematoda of Greenland.***—M. G. M. R. Levinsen describes the following new species of this group: *Distomum Muelleri*, *D. mollissimum*, *D. oculatum*, *D. sobrinum*, *D. somateriæ*, *D. pygmæum*, *Gyrodactylus grœnlandicus*, and *Bucephalus crux*; the last species receives its specific name from the possession at the hinder end of the body of three cylindrical appendages, which are so set as to form with the body the figure of a cross.

**Excretory Organs of the Trematoda and Cestoda.**†—M. J. Fraipont directs attention to some points, of which we have not yet taken notice. In the lower forms the system is typically formed of two longitudinal canals, which extend throughout the whole length of the body, and either open to the exterior directly, or by the intermediation of a vesicle with a single median orifice. These longitudinal

* Overs. K. Danske Vidensk. Selsk. Forh., 1881, pp. 52–84 (2 pls.).
† Bull. Soc. Belg. Micr., vii. (1881) pp. xxxi.–xlii.

canals ordinarily give off delicate lateral canaliculi, which anastomose with one another and ramify throughout the body. In the *Rotifera* we find the origin of these ductules; they open by ciliated infundibula into the cœlom. In some Rotifers there are no ductules, but the infundibula open directly into the longitudinal canals. In some of the lower Flatworms the ductules have no cœlomatic orifice. In the annulated worm the "urinary apparatus is multiple; typically, there is a pair of organs in each segment," which are placed on either side of the middle line. The coiled tube opens by one or more infundibula into the cœlom. In certain types (*Gephyrea* and embryonic Hirudinea) the two sets of excretory organs are found coexistent. Of late years somewhat similar structures have been observed in adult or embryonic stages of the Vertebrata. The question arises, Are these three sets of organs homologues or only analogues? After discussing the observations on which we have already reported, the author would appear to incline to the former view.

Embryonic Development of Tænia.*—M. E. van Beneden enters into a detailed account of *T. serrata*, and a more summary account of the embryo in *T. saginata* and *T. porosa*. In discussing the morphology of the albuminogenous layer which, with the granular layer, forms a complete envelope for the embryo, he affirms its resemblance to the membrane he previously observed in *T. bacillaris*. Between *T. bacillaris*, in which the number of cells is considerable, and *T. porosa*, in which they are few, we have the two others just mentioned to represent intermediate stages. This envelope is, further, homologous to the ciliated investment of *Bothriocephalus*, and both have the same developmental history; *B. proboscideus* has no cilia. The author feels himself justified in supposing that the covering in question is the last vestige of an embryonic membrane which was primitively ciliated, that it lost its cilia, that the cells became reduced in number, and the membrane a mere rudimentary organ.

The author observes that the ovum of the Tæniadæ undergoes unequal segmentation, and he thinks that the albuminogenous cells are the product of a kind of precocious epidermal ecdysis; the cells tend to envelope, by epiboly, the mass of embryo-cells.

After discussing the ciliated investment of *Bothriocephalus* as a provisional organ, M. van Beneden points out that the hexacanth-embryo is constituted at first of two layers of cells, a superficial one, in which the chitinous hooks are developed, and a medullary mass, which at first is incompletely covered by the superficial layer. "Are these two layers homologous with the primitive layers of the other Metazoa? In the present stage of our knowledge it is not possible to prove that it is so; but, at least, it is rational to suppose it. Further studies on the organization and development of the hexacanth-embryo are necessary for us to be able to say definitely whether the two layers which I have noticed at the commencement of the formation of the embryo are or are not homologous with the primitive layers of the *Gastrula*."

* Arch. de Biol., ii. (1881) pp. 183–211 (2 pls.).

**Germinal Layers of Planarians.***—Professor E. Selenka's communication to the Society of Erlangen is here abstracted; he finds that in *Eurylepta cristata* the ova are only fertilized after deposition, and he notes that only one spermatozoon enters the egg; the blastopore appears at the vegetative pole. The first two blastomeres are generally of a different size; their appearance is followed by that of two small cells, and then it is seen that the largest blastomere is dorsal, the next largest ventral, and that the two smallest respectively occupy the right and left sides. At the anterior pole four small ectodermal cells appear, and four formative cells lie below these; they give rise to four small mesodermal cells, which are the seat of origin of the muscles and of the reticulum, and so, therefore, of the tissue which surrounds the ramifying branches of the enteron. At the posterior pole there are seen four very small endodermal cells, which form the proboscis; a diagram is given in illustration of the topography of these parts. The author would seem to have found that the blastopore is persistent, and that it forms the permanent mouth. The gastrula is formed by epiboly.

*Leptoplana tremellaris* differs in having the blastomeres of the first and second orders equal to one another in size, as well as by the fact that there is no metamorphosis during the course of development.

## Echinodermata.

**Echinodermata of the Gulf of Triest.**†—In giving a list of these forms, Dr. E. Graeffe adds notes on the places in which they are to be found, and as to the season of reproduction. He points out that the developing forms have many enemies, whereas, so far as he knows, the adults have none; and he reminds us that large forms at any rate have a peculiarly disagreeable smell, which would aid them, in addition to their spines; he says that it is rare to find Echinoderm-remains in the stomachs of predatory fish. This circumstance would explain the absence of any characters which could be referred to mimicry, and the possession of the peculiarly bright coloration which they so frequently exhibit. In some notes on their development he states that in the first half of the year the *Auricularia*-form predominates, and in the second the *Pluteus* and *Bipinnaria*. No information could be obtained as to the length of time necessary for the small non-embryonic form to attain to its full size or to generative maturity. As to their habits, we can only note that the sea-urchins cover themselves with algæ, shells, &c., and lie in wait for small fishes and Crustacea. As is well known, the starfishes are fondest of Mollusca.

**Revision of the Holothuroida.**‡—Dr. H. Ludwig gives a revision of the species of Holothurians collected by H. Mertens and described by J. F. Brandt. He sinks the genera *Oncinolabes*, *Liosoma*, and *Aspidochir*, and the family Oncinolabidæ formed by Semper later on. He finds that of the twenty-three species described only six have not

* Bull. Sci. Dép. Nord, iv. (1881) pp. 165–9.
† Claus' Arbeiten, iii. (1881) pp. 333–44.
‡ Zeitschr. f. wiss. Zool., xxxv. (1881) pp. 575–99.

been described by earlier or later authors under other names, with the exception of one (*A. Mertensi*) among these seventeen, which has been insufficiently characterized. The species that are held good are—*Cucumaria albida*, *C. nigricans*, *Stichopus chloronotus*, *S. sitchaensis*, *Holothuria sordida*, and *H. tigris*. The synonymy of the different species is amply dealt with, and some remarks are made on each of them.

**Observations on the Echinoidea.***—Prof. F. Jeffrey Bell in his fourth part deals especially with the Echinometridæ, their affinities and systematic position. He points out that the discoveries of late years make it now easier to propose a scheme of classification of the regular Echinoidea. Adopting the divisions suggested by Ludwig, which depend on the possession or absence of external gills, and recognizing the significance of *Echinothuria*, to which, as possessing more than one pair of each series of ambulacral plates carried on to the buccal membrane he applies the term *polylepid*, he distinguishes the rest of the branchiate Echinoids as *decalepid*, as, in them, only five pairs of ambulacral plates are found on the buccal membrane. Of these the Salenidæ are *palæoproctous*, while the rest are *neoproctous;* among the latter some of the primary pore-plates always lose their primitive relations; but in the Arbaciadæ and Diadematidæ this does not always affect the plates above the ambitus, and the poriferous zones are in both almost straight; they are *palæosticha*, as compared with the Echinidæ and Echinometridæ, which are *neosticha*.

These relations are exhibited in the subjoined table:

"No external gills. Auricular arch not complete and not radial. Ambulacral and interambulacral plates continued on to buccal membrane; pores in straight rows, all the pore-plates primary and subequal. ENTOBRANCHIATA.

Fam. 1. *Cidaridæ*.

External gills, auricles radial; interambulacral plates not continued on to the buccal membrane. ECTOBRANCHIATA.

Series $\alpha$. (Palæoproctous.)

Large suranal plate persistent in apical area.

Fam. 2. *Salenidæ*.

Series $\beta$. (Neoproctous.)

Anal plates all secondary.

Subseries i. (polylepid).

More than one pair of ambulacral plates carried on to the buccal membrane from each area. Fam. 3. *Echinothuridæ*.

Subseries ii. (decalepid).

Only five pairs of ambulacral plates on the buccal membrane.

* Proc. Zool. Soc., 1881, pp. 410–33 (2 figs.).

A. Auricular arch not complete. Fam. 4. *Arbaciadæ.*
B. Auricular arch complete; rudimentary internal gill still retained. Fam. 5. *Diadematidæ.*
C. Auricular arch complete; no rudimentary gill. Fam. 6. *Echinidæ.*

On the characters here detailed Professor Bell is led to place the Echinometridæ in the same family as the Echinidæ. Though this is contrary to the views of Gray and Agassiz, it appears to be supported by histological observations; and though his system refuses to make use of the convenient separation of Desor, by means of which genera were grouped under the *Oligopori* or *Polypori*, it seems to be supported by the history of the development and the variations in the number of primary pore-plates which fuse to form a single secondary plate. It is pointed out that there is no real difference in the "mode of growth of the poriferous zone," as A. Agassiz believes, and it is urged that "whatever be the significance of the obliquity of the morphological axis, there can be little doubt that it is of very great importance." The Echinidæ are, therefore, thus arranged:

Group I. Body circular. ECHININÆ.
(α) Secondary plates formed of three primary plates, e.g. *Echinus.*
(β) Secondary plate formed in adult of three or more than three primary plates, e. g. *Strongylocentrotus.*
Group II. Morphological axis set obliquely to long axis of test. ECHINOMETRINÆ.
Group III. Morphological axis set at right angles to long axis of test. HETEROCENTRINÆ.

It is urged that *Heterocentrotus* and *Colobocentrotus* stand further from the Cidaridæ than do *Tripneustes* and *Tonopneustes*, for in the former there appear to have culminated "the elaborateness of the ambulacral plate, the strength of the spines, and the size of the buccal apparatus."

The great body of the paper is made up of percentage measurements and other observations on the groups united by Agassiz under the head of "*Echinometradæ*," to which we have no space to refer.

**Crossaster.***—Professor Jeffrey Bell points out that no definite diagnosis of this genus, as distinguished from *Solaster*, has yet been given, and he directs attention to the fact that when we examine the actinal surface of a ray of *Solaster endeca* we observe that, externally to the transverse set of spines which runs near the ambulacral groove, there is a series of special plates bearing a comb of spines; though in a sense marginal, these plates are quite confined to the actinal surface; from the dorsal view one would not have the least suspicion of their existence. It is not so with *C. papposus*, for there the modified marginal plates are set on the upper part of the side of the ray, and form a regular series of dorso-marginal plates. Coming lastly to *Lophaster*, we find that the "differentiated marginal

* Ann. and Mag. Nat. Hist., viii. (1881) pp. 140–2.

plates" of which Professor Verrill speaks exhibit a striking advance on what has been seen in *Solaster* or in *Crossaster;* there are now two sets, one dorso-marginal and one ventro-marginal. The writer submits that this gradation points to the presence of three distinct though allied genera. A new species *C. neptuni*, from the coast of Ecuador, is described.

### Cœlenterata.

**Origin of the Ovum of the Hydroida.***—M. A. de Varenne, who has examined *Campanularia flexuosa*, *Plumularia echinata*, and *Sertularia pumila* at Roscoff, finds that the ovum is not developed in the gonophore, but in the stem of the hydroid. Examining a form, *Gonothyræa Loveni*, in which the gonophore becomes an attached Medusa, he again noticed that the ovum arose from the endodermal cells of the stem, while the same observation was made for the eggs of *Podocoryne carnea*, and *Obelia geniculata*, in which the gonophores become free-swimming Medusæ. The author insists that the ova are not developed within the gonophore, that every stage can be made out between them and the ordinary endodermal cell; and he comes to the more general conclusion that neither the buds, the gonophores, or the Medusæ can be rightly looked upon as sexual individuals.

**American Acalephæ.**†—Mr. J. W. Fewkes describes as new *Lafoëa elegans*, *Campanularia insignis*, *Sertularella formosa*, and *Plumularia caulitheca*, which, unlike other species of the genus, has a large nematophore, not free as the others of the same species, which arises from the stem upon the upper side of a projection of the hydrocaulus from which the pinna springs; also *Aglaophenia insignis*, *A. gracillima*, *A. minuta*, *A. crenata*, and *A. robusta*. *Aglaopheniopsis* is a new genus which resembles somewhat *Macrorhynchia*, but does not have the pinnæ carrying gonophores; like *Halicomaria*, it has a nematophore modified into a long jointed stalk, but, contrary to what happens in that genus, these appendages are not confined to the proximal hydrotheca (*A. hirsuta*). *Antennopsis ramosa* is a new species. The new genus *Callicarpa* (*C. gracilis* and *C. compressa*) differs from all known genera of Hydroids in having a gonosome which closely resembles a spike of wheat, and springs by a short peduncle from the main stem. The new genus *Pleurocarpa* (*P. ramosa*) has likewise a peculiar gonosome, which is formed from the proximal portion of a branch, while the distal end of the same retains the true characters of the branch, and bears pinnæ.

**Jelly-fishes of Narragansett Bay.**‡—Mr. J. W. Fewkes points out that a portion of the base of the tentacle of *Sarsia mirabilis* is specialized into a spherical body, which projects downwards as the jelly-fish swims in the water, hanging below the margin of the bell. The cellular bodies in the wall of this enlargement "indistinctly resemble lasso-cells," but appear to have some special function.

* Comptes Rendus, xciii. (1881) pp. 345–7.
† Bull. Mus. Comp. Zool., viii. (1881) pp. 127–39 (4 pls.).
‡ Ibid., pp. 141–76 (10 pls.).

In giving an account of *Lizzia grata*, the author points out that *Lizzia* passes through a *Dysmophorsa* and *Margellium* stage, and has the power of germination throughout them both, and he concludes that Haeckel is not justified in his formation of new genera "on what are surely embryonic features."

*Mabella (M. gracilis)* is a new genus in which alone budding takes place from the proboscis of a hydroid medusa with *eight*, or more than four, chymiferous tubes.

*Modeeria multitentacula* is a new species described from the notes and sketch made by A. Agassiz. *Dinematella (D. cavosa)* is another new genus, the examples of which have often been confounded with *Stomatoca apicata;* it differs, however, in the colour, shape of the ovaries, and by the presence of a cavity in the apical portion of the bell; the contents of the cavity are liquid, and identical with that found in the marginal and radial tubes; but the space does not seem to be, as in Ctenaria, a brood-pouch.

After notes on several forms already described, we come to *Eutima gracilis* n. sp., which is distinguished from its allies by the presence of a pair of lateral "spurs" or thread-like appendages on each of the rudimentary tentacles. A new genus of the *Trachynemidæ* is *Sphærula (S. formosa)* which is allied to *Eurybiopsis;* there is no peduncle to the proboscis, and there is an open cruciform mouth; no oral tentacles or knobs. *Cunina discoides* is a new species.

Towards the conclusion of his paper the author enters into a descriptive and critical account of the sense-organs found on the bell-margin of *Cyanea arctica*, and describes certain structures which he thinks previous naturalists have overlooked.

Æquorea Forskalea.*—Prof. C. Claus, while giving an account of this Adriatic Medusa, takes the opportunity of making some criticisms on Prof. Haeckel's classification of the *Æquoridæ*. A careful study of this form has shown Claus that it is subject to extreme variation; variations so great as to have led Prof. Haeckel to make a number of genera and sub-genera for their reception. It is not possible to abstract a critical paper of this kind, and we must be content to direct attention to the following points. Claus finds that the colour varies with age and sex; the young may well be called *vitrina*, as Gosse called them; later on blue pigment-granules may appear in the ectoderm, and especially in the gonads of the male, while the female may take on a more or less reddish coloration (the *A. violacea* of Milne-Edwards). The radial canals vary in number from just over fifty to nearly eighty. The form and size of the mouth-lips depend on the state of contraction of the specimen, on its age, and on the breadth of its umbrella. Altogether, according to Prof. Claus, Haeckel would seem to have afforded a very interesting proof of the origin of species by variation.

Notes on Limnocodium.†—Professor Ray Lankester has been able to make a study of the endodermal cells of the fresh-water Medusa

* Claus' Arbeiten, iii. (1881) pp. 283–312.
† Quart. Jour. Micr. Sci., xxi. (1881) pp. 119–31 (3 pls.).

with the especial object of studying its intracellular digestion. He finds that the cells of the endoderm of the gastric tube and gastro-vascular canals differ very considerably in form, and in the chemical metamorphosis of its substance in different regions. Thus in the gastric tube itself the oral cells produce a secretion, the cells of the mid-gastric layer are inactive, while those of the proximal or ingestive region are the only ones that exhibit intracellular digestion. During life there were observed in this portion green unicellular organisms, large Euglena-like forms, or smaller Protococci. The cells appeared to be naked, and to have pseudopodia-like processes; they unite to form a meshwork in which there are large intervening spaces. Secretion-cells are also to be found in this layer, and these are swollen and granular when the cells of the oral region appear to have been shed and have left intercellular spaces. On the other hand, the oral secretion-cells are richly developed when the cells of the proximal region are exhibiting the phenomena of intercellular digestion. Professor Lankester infers that this is seen in a state of comparative fasting, in which such small bodies as may be ingested by the endoderm of the proximal region are proportionally valuable to the organism. The other condition would appear to obtain when relatively large prey has been taken into the gastric cavity.

In some observations on its development,* Professor Lankester compares it with *Geryonia*, and he thinks that Haeckel's observation, according to which the sub-umbrellar cavity is formed as a closed space between two layers of the ectoderm, is correct. He points out that this sub-umbral sac corresponds with the so-called stomach of the Ctenophora and its opening with their so-called mouth. In both cases it is lined by ectoderm, and developes quite independently of the endodermal cells, which give rise to the stomach and canals of the Hydromedusæ on the one hand, and to the infundibulum and canals of the Ctenophora on the other.

**Medusæ and Hydroid Polyps Living in Fresh Water.**—Mr. Romanes, writing † with reference to the remarks of Prof. Agassiz, which we quoted at p. 968 of vol. iii., says that he has made no experiments or statements with reference to the effects of *brackish* water either in estuaries or elsewhere, his experiments consisting merely in *suddenly* transferring Medusæ from sea water to *perfectly fresh* water.

### Porifera.

**Propagation of Sponge by Cuttings.**‡—The 'Journal of the Society of Arts' contains an abstract of an account given by Dr. E. v. Marenzeller of the efforts made by the Austrian Government to improve sponge culture in the Adriatic, from which the following is condensed.

Prof. O. Schmidt expressed a conviction that if a perfectly fresh sponge were cut into suitable pieces, and these were again placed in

* Quart. Journ. Micr. Sci., xxi. (1881) pp. 194–201 (1 pl.).
† Ibid., pp. 162–5.
‡ Journ. Soc. Arts, xxix. (1881) pp. 592–4.

the sea, they would grow, and in time become perfect sponges. This was put to the test by an experiment conducted in the Bay of Socolizza, commenced in 1863 and concluded in 1872. Though success was rendered impossible by the determined opposition of the local populace, it did not prevent the accumulation of a mass of valuable information.

The most suitable season for commencing the propagation is the winter. The growth of the sponge, and the healing of the cut surfaces, proceed much more slowly in winter than in summer; but a high temperature is dangerous, by reason of the great tendency of the sponge to undergo rapid putrefaction.

As to locality, choice should be made of bays sheltered from strong waves and currents, but not quite still; the bottom should be rocky, and clothed with living algæ; and there should be a moderate ebb and flow of the tide. In all cases, the neighbourhood of the mouths of rivers and subterranean springs must be avoided. The freshness and liveliness of colour of the marine algæ are sure indications of a suitable spot. The worst enemy of sponge culture is mud.

The sponges chosen for cutting must be gathered by experienced hands with all possible gentleness. They are removed either by tongs or by drag-nets.

At a low temperature in the cold season of the year, it is possible, with sponges freshly caught on the spot, to proceed at once to make cuttings from them; whilst during warm weather, it is necessary to wait and see whether any signs of putrefaction make their appearance. This reveals itself by the dulness and softness of the affected part.

The dissection is rapidly performed, either with an ordinary knife, or better, with a fine saw-like blade, which is much less liable to injury by the foreign matters so abundantly found in sponge. The sponge is laid upon a smooth wooden board, moistened with sea water. The size of the cuttings is usually about 26 c. mil. (1 cubic inch). It is well that each cutting should have the greatest possible area of uninjured outer skin. The cuttings are placed directly in the spots where they are intended to resume growth.

A healthy piece of sponge firmly attaches itself to any surface with which it comes into intimate contact in a short time. Cut sponges grow together again. The attachment takes place most rapidly when the pieces have but one cut surface, and this is laid upon the support—wood, stone, &c. During perfect calm, for at least twenty-four hours, it is possible, according to Buccich, to plant the cuttings upon the stony sea-bottom itself, and they will hold. He saw pieces that were merely cast into the sea on an ordinarily suitable rocky bottom, during perfect calm, attach themselves and grow. Thus enlightened as to the natural habits of the sponge, Buccich prepared stone slabs, 53 mm. thick, as a foundation. These he perforated with holes, and fastened the cutting to them by wooden pegs driven into the holes; but it became evident that the mud and sand of the sea-bottom, perhaps also excess of light, were inimical to further growth. Lattice frames, having the form of floating tables above, and with the sponges attached beneath, were tried. Prof.

O. Schmidt also suggested merely tying the cuttings to strong suitable strings. By the first plan there was too much shade; by the second, too much light. Buccich first constructed an apparatus composed of two planks crossing each other at right angles, with a third as a cover. This was so far successful that the cuttings were exposed on all sides to the sea, and assumed the desirable round form. He then made a modification consisting of two boards, 63 cm. by 40 cm.; one forms the bottom and the other the lid, and they are held parallel one over the other at a distance of 42 cm. by two short stays, some 11 cm. apart. In the space between these stays, stones can be placed as ballast; on the top of the cover is a handle. In both planks holes are bored at 12 cm. apart. Buccich fastened the cuttings not simply on the apparatus, but on sticks which were driven into the holes of both boards. As material for the sticks the common Spanish cane was used, whose siliceous rind is proof against the attacks of the pile-worm. The sticks were 42 cm. long, and bored through at a distance of 12 cm., the lower end being split. On each stick three sponge-cuttings were fastened in such a manner that they should lie over the bore-holes; through these, wooden sticks were thrust, and each cutting was thus fixed.

When the sponge-cuttings are to be pegged only with wooden nails, a triangular stiletto will suffice for piercing. When adopting the method of fixing by sticks, such an instrument is not suitable, because much too great force would be required to make an opening to admit the sticks. Forcing and squeezing causes a loss of sarcode, the minimizing of which is the first rule that governs all manipulations of sponge. Buccich bored the cuttings with an auger with toothed edges, 6 mm. broad, fixed to a vertical wheel driven rapidly by a little pulley. While one hand quietly presses the sponge against the borer, the other turns the wheel. In a few seconds the operation is concluded; the bore-hole is clean, the fibres are not torn, and the sarcode does not run out. When a stick is filled with cuttings, its split end is thrust into one of the holes in the support, and a wedge is driven through the slit. As each bottom and top takes 24 sticks, carrying three cuttings apiece, one such apparatus will accommodate 144 cuttings.

During the whole manipulation, until the arranging of the sponges is quite complete, they must be repeatedly and gently moistened with sea water, especially in summer. The apparatus may be most conveniently let down and pulled up by means of a small anchor. The depth may be 5 to 7 metres.

If the cuttings hold fast after three or four weeks the propagation is secure. A characteristic feature of the cuttings is their tendency to assume a round form. To facilitate this on every side is the chief aim of Buccich's system of supporting on sticks. As to the rate of growth of the cuttings within a certain period, no rule can be given, on account of the varying conditions. Buccich remarked that the cuttings in the first year were two or three times as large as they were originally; he further remarked that the cuttings grew better in the first and fourth years than in the second and third—a point evidently

regarded as doubtful by Dr. Marenzeller; and it would seem that though some specimens may have attained a considerable size in the fifth year of transplantation, still a term of seven years is necessary to produce a marketable and profitable article. Dr. Marenzeller also mentions the fact that, besides being beautifully formed and rounded, the cuttings retain these qualities, and perfect health, with increasing size.

In conclusion, Buccich proposes the question whether the undertaking can be made profitable, and answers it in the affirmative. Dr. Marenzeller concludes that the propagation of sponge by cuttings is not to be recommended to people without capital, but is more suited to the attention of a capitalist, or an association of capitalists, and to be conducted on a large scale.

**Organism which penetrates and excavates Siliceous Sponge-Spicula.***—Professor P. Martin Duncan, referring to his paper at p. 557, says that since writing it he has observed siliceous sponge-spicula, obtained from great depths, which are affected by an organism (probably a plant, and named by the author *Spongiophagus Carteri*) whose cells are much larger than those he previously described, and whose penetrations, therefore, are wider and much more visible. On the head of a large spinulate spicule he found many circular pits, each containing an organic mass without definite cell-wall, and yet granular and green in colour by transmitted light. These pits are shallow, and are $\frac{1}{2000}$ inch in diameter. Similar pits and of the same dimensions are seen on other spicula; but they are deep, and resemble cylindrical tubes with hollowed-out bottoms. Some reach the axial canal, which has become enlarged. The penetrations contain granular organic substance, and so do the enlarged axial canals. The walls of the enlarged axial canals are frequently very irregularly eroded, and look "worm-eaten"; the hollows are, moreover, green with the very visible granular matter. It is evident that the assimilation of the organic substance in the sponge-spicule by the vegetable organism produces the destruction of the siliceous structure; and probably the colloid silica unites with the protoplasm of the destroyer and forms an organic compound with it. Large cells and small nucleus-like cells operate, producing penetrations of corresponding diameters through the spicula down to the axial canal. The vegetable growth occurs there, and the amount of erosion does not appear to be in relation with the size of the primary penetration.

The organism is not an *Achlya*; and all that can be said is that it consists of cell-like bodies without very definite cell-walls, but evidently with a very delicately limiting texture, surrounding a granular greenish plasma, and that there is much free and non-cellular plasma with bodies like small nuclei, the whole having a faint green tint.

### Protozoa.

**Structure of Unicellular Animals in General.**†—M. Ch. Robin thinks that "when considering the essential conditions for the fulfil-

* Ann. and Mag. Nat. Hist., viii. (1881) pp. 120–2.
† 'Journ. Anat. Physiol.' (Robin), xv. (1879).

ment of those actions termed organic or vital, it is of importance to know to what degree the anatomical and physiological complexity of the independent beings called *unicellular* may be carried; that is, of those independent organisms which are incontestably the homologues of the *anatomical units* of compound living bodies. It is also important to know whether a unicellular animal or vegetable of independent habit of life is to have one additional elementary part or several—unlike, though homologous—added to it by that process of gradual structural complication which is the result of its development; whether, that is to say, this being, which has the structure of a fertilized ovum, imitates its development also by leaving the cytode, or unicellular stage, for that of a multicellular organism, composed of dissimilar cells, which only reproduces the original unicellular form at a later period.

Now, there is a fact in the history of the acinetine form *Podophrya* which is also observable in all other unicellular animals and plants. It is that during those phases of its reproduction in which the production of gemmæ causes them temporarily to pass through the multicellular stage, each gemma, or cell, already represents a new independent individual. It does not represent a constituent part associated with other parts to make up a new multicellular organism, which, in this condition, with or without increase of structural complication—that is, with or without the addition of anatomical units, and new organs, combining to perform in harmony certain actions—undergoes further evolution. The multicellular condition by no means represents the transition from one degree of organization to a superior one, but only a temporary addition to an individual of other individualities, which are already distinct from each other, and which are continually less and less forming part of the organism from which they are derived, instead of the opposite being the case, as in growth, properly so called.

Thus the body of *Podophrya* does not represent an ovum any more than does that of the other unicellular organisms. The Infusorian is a plant or an animal, as the case may be; but it is neither an *oophyte* nor an *oozoon*, nor, above all, indifferently either the one or the other according to the media in which it is placed. Besides, independently of its peculiarities of structure, and often of the reactions which allow us to distinguish the ovum, whether animal or vegetable, from a protozoan or protophyte, it must be noted that no ovum engulphs foreign particles in order to digest them, and to further its own development, as do so many Infusoria.

The structural complexity of the unicellular animals may in such forms as the Noctilucæ and the Infusoria, go the length of producing a tentacle and a flagellum, a true mouth-opening, with more or less elaborate lips, &c. In a number of Infusoria, both ciliated, acinetine, and flagellated, besides the cilia of the one, the radii or suckers of the second, the flagellum of the last, and the pulsatile vesicle which is wanting in the adult Noctilucæ, there may occur a more or less complicated shell and peduncle. In these last we have so many genuine organs, fulfilling uses which are very distinct from

those which are assigned to the wall and body of the cell, and similarly from those of the other parts.

At this point we cannot insist too strongly on this other fact, that, from the condition of a unicellular organism with independent existence, each of these cells has already produced, owing to the actions of assimilation and dis-assimilation which go on in it, parts exterior to itself, namely, tegumentary and skeletal structures—organs which are not cellular, although they present morphological arrangements often of a very complicated nature.

We see, then, that from the unicellular state animals produce skeletal parts of comparative complexity, homologous with those which are, in the pluricellular forms, of ectodermal origin. These parts, without being cellular, assume, as early as in the Sertularians, great importance with regard to the constitution and maintenance of the system, while above the Worms, Mollusca and Articulata (in many of which they may form the most considerable part of the organism), they find as homologues only the scales of fish, the teeth, the proper walls of the notochord, the crystalline lens and the glands, the shells and capsules of ova, and some other parts which agree with them in not being cellular, in spite of the frequently great complexity of their intimate or structural arrangements.

Further, it may be noticed even in the ciliated Infusoria, that special non-cellular structures of different kinds appear, which may or may not be tegumentary, but are the homologues of the ectodermic structures of the multicellular organisms. Such a structure is the curious and complicated organ of corneous, or rather chitinous appearance, shaped like a toothed wheel, which *Trichodina* possesses. The animal in this case is represented by a single cell, and is already producing non-cellular organs as complex, characteristic, and important as their analogues which have the form of hooks, &c., and which are observed in the multicellular parasite of *Ophryodendron*, and in numerous Turbellaria, Trematodes, Cestodes, &c. The most important of these organs are those of skeletal character.

In point of fact these are real *units*, considered both anatomically and physiologically. The doctrine of anatomical elements, as divided into cellular and non-cellular, takes account of them; not so the cell theory, which looks at nothing but what is either a true cell or takes the form of *monera* or *plastids;* but that is immaterial.

The importance of this subject arises from the fact that the skeletal structures above noticed, impart habitually to the Protozoa a semblance of being multicellular or at least bicellular organisms. This is the case especially with all those numerous forms among the ciliated, flagellated, cilio-flagellate and Acinetine Infusoria which are provided with a shell or theca, with or without a peduncle.

In the *Podophryæ* and *Acinetæ* more particularly, it is not only the theca which takes morphologically the aspect of a cell or cell-wall, without sharing its structure. In *Podophrya*, the peduncle is the part which gives a bicellular appearance to the perfect animal: regarding the body as a whole as a cell, and as forming by itself a single cell in the anatomical and physiological meaning of the word,

one must consider the peduncle to represent a second cell, but only from the morphological point of view: the short forms of this pedicle show this point the most clearly. Besides, this cell is elongated like many vegetable cells.

This peculiarity is also manifested by the Acinetæ. But in them this organ is much more delicate, and has the appearance of a colourless thread. But notwithstanding a wall with parallel sides quite distinct from the cavity is as clearly to be distinguished as in the broader peduncle of *Podophrya.* It may be also made out that this peduncle is not a tube open at the two extremities nor continuous in its substance with that of the side of the theca; it is closed at its upper end as well as at the lower one, which is fixed to various objects. This fact is easily determined when the cell and its shell, constituting the body of the animal, are detached from their base. But if this latter organ is a cell, in the general acceptation of the term, it is not one in its anatomical import; for it has at no period of its existence a nucleus.

Thus this part of the organization does not, from this point of view, represent a passage in these animals from the unicellular to the multicellular state, any more than it does when considered in its structural details. It is an example of an additional complexity imparted to the organs of unicellular beings by their non-cellular parts which must be added to the instance above cited; that is to say, to that part of the organization of a protozoan or a protophyte which presents the condition of a cell are added one or more parts which are also organized, but to which the idea of a cell does not apply. Now, the number of these constituent parts of the economy goes on increasing in proportion as the economy itself becomes more complex. Also, although it is said by those who maintain that the idea of the cell is sufficient to condense and sum up in itself the idea of an organism, that there is nothing in anatomy outside of the study of the cell or compounds formed of cells, it will be seen that, when one does not even yet know what parts are cellular, much still remains to be done. In particular, it will be seen that, with regard to the Protozoans on the one hand, and the Protophytes on the other, we should have an imperfect idea of their constitution if we were limited to the examination of the cell, which is its chief, but not its only factor.

We see once more that the notion of the cell is not enough to include everything in both elementary anatomy and physiology, and that organisms possess other things than those which occur under the form of cells.

On the other hand, viewing life as a state of movement, and not of mere equilibrium, we ought, in speaking of what is the constant element of every primary form of organized substance, to term it a *physiological unit*, just as the phrase *anatomical unit* is applied to the form itself. In fact, every element, cellular or non-cellular, represents a *physiological unit* from this point of view; but it is important to note that it is only among the *cellular units* that any are found to be endowed with the properties described as belonging to animal life on the one hand, and even—as occurs to some extent—

with reproductive properties on the other. We know, in fact, that the non-cellular elements are produced by those which are cellular, and that their generation and reproduction are subordinated to those of the latter; they nourish themselves and develope, but always remain devoid both of contractility and nervous power; they may undergo regeneration, but do not reproduce directly.

Of course that which is called a *physiological unit* is confused, as we have seen in the case of the Protozoans, with that description of the organization of the cell which describes it as an *anatomical unit*, and the expression is only true when used in a general or abstract sense. However, *Podophrya Lyngbyei* (e. g.) in the larval stage, is a good example of both an anatomical and physiological unit. But it is certain that by virtue of their peduncle, of their theca which is separable from it, and of the body which is separable from the theca, the adults of *Podophrya* and the Acinetæ are Protozoa in which are found at least two kinds of anatomical and physiological units: the one of these, namely, the non-contractile theca and its peduncle, is subordinate to the other, the sarcode body, and it remains essentially different from it in anatomical and physiological characters.

With regard to the study of the unicellular animals, it is evident how wide of the truth those are who consider everything in anatomy to consist in the study of the form and morphological arrangements of these beings at whatever stage they are examined ; for though they adopt these primary and necessary ideas, they omit that which, by explaining the nature of the factors which go to make up the forms of organized bodies, furnishes a biological analysis which is in accordance with theoretical and scientific principles and determines the essential characters of those bodies. Now, it is this power, which is the real basis of general anatomy, which constitutes it a science capable of ranking with the other branches of anatomy, which forms it into a compact whole, and enables it to explain the origin of the parts which possess volume, colour, consistence, and shape of various kinds.

It becomes still more seriously manifest how much is still left to be done or to be done over again when we turn to the more important study of embryogeny, and point out only those forms and analogies which are expressed by the terms *morula*, *gastrula*, &c., and secondly the forms assumed by the layers of the blastoderm, without going into the precise meaning of the different kinds of cells which constitute these forms, or of those cells which become the exact point from which this or that transitory or permanent organ takes its origin. All this series of *forms* is in reality only the result of groupings of cells which are stages between each form of organ and its successor, the result as much of the life of nutrition, which resides in the animal, as of that of reproduction, locomotion, and innervation. The only result attained by those who would regard biology as independent of chemistry—which discovers the intimate character of bodies—and anatomy as limited to morphology and not needing the ideas furnished by elementology, will be the knowledge of the surface of the matter, without arriving at those conclusions which supply

logically, that is, scientifically, the reasons for the existence of things."

**New Infusoria.***—C. Mereschkowsky describes some new species of Infusoria—one from the White Sea, three from the Black Sea, and two from the Bay of Naples.

From the White Sea are *Acineta saifulæ* (Pl. X. Fig. 4). From the Black Sea *Cothurnia pontica* (Fig. 3); *Trochilia marina* (Fig. 2); *Acineta livadiana* (Fig. 5); and from the Bay of Naples *Tintinnus mediterraneus* (Fig. 1) (also in the Black Sea), and *Anisonema quadricostatum* (Fig. 6).†

The author's view that the marine Infusoria of different seas differ much more than the fresh-water Infusoria of different countries ‡ is confirmed, he considers, by the Infusorial fauna of the Black Sea. The marine species, all more or less frequent there, were not met with in the White Sea, while there was not a single fresh-water species observed in the Crimea or Caucasus that was not also found in the Arctic Regions of Northern Russia.

**The Tintinnodea.**§—H. Fol deals with the structure, classification and synonymy of this obscure family of Infusoria.

The body (Pl. X., Figs. 7 and 9) is conical, terminated above by a broad disk, and produced below into a contractile appendage, which is longer or shorter according to the species. Energetic as are the contractions of this peduncle, it does not present that transverse striation, recalling the texture of the striped muscles, which characterizes the peduncle of the *Vorticellæ.* Stein has observed that, when the animal detaches itself from its test, the peduncle enters into the body and becomes confounded with it—a proof that it consists of sarcode with no special differentiation.

The superior discoidal extremity or peristome, when the animal is extended, is placed a little obliquely with relation to the aperture of the test. This position and the long cilia give it a great *apparent* resemblance to the disk of the *Vorticellæ;* but the mouth, instead of being placed at the outer margin of the disk, as in the *Vorticellæ*, is in its interior, and often even near its centre; whilst the disk itself, instead of being flat or slightly convex, is hollowed out like a saucer; and the vibratile cilia, instead of forming a single row round the margin of the disk, are implanted in great numbers and in several lines over the greater part of the surface.

The arrangement of these vibratile cilia is exceedingly curious and interesting, and has not been previously described.

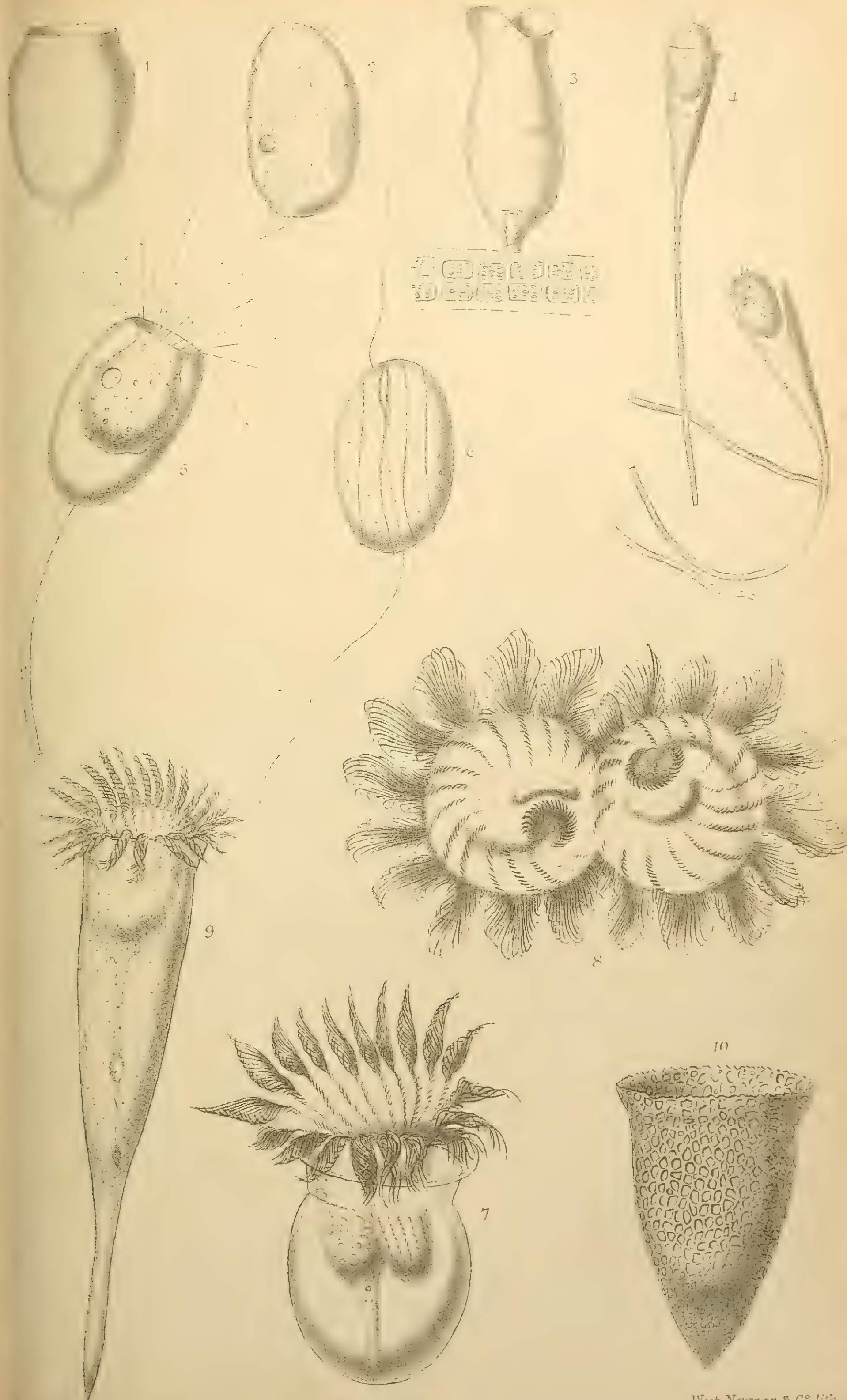
The whole margin of the disk is occupied by long and strong motor cilia, which strike the water vigorously and give the animal

* Ann. and Mag. Nat. Hist., vii. (1881) pp. 209–19 (1 pl.).

† *Cothurnia socialis*, though found subsequently by A. Graber, was first described by him (see vol. iii. (1880) p. 284); and *Urceolus Alenzini*, also now described and figured, was published by the author in 1877 (see also vol. ii. (1879) p. 277). Both are from the White Sea.

‡ See vol. ii. (1879) p. 277.

§ Arch. Sci. Phys. et Nat., v. (1881) pp. 5–24. See Ann. and Mag. Nat. Hist., vii. (1881) pp. 237–50 (1 pl.).

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an exceedingly rapid rectilinear movement. In this way it habitually swims, turning on itself during its progress; but it can readily deviate from the direct line when it has to avoid an obstacle.

The other cilia which garnish the upper surface of the disk are arranged in parallel lines, all curved in the same direction and running from the margin of the peristome towards the mouth. In one species Professor Fol counted twenty-four of these rows. The mouth occupying an eccentric position, the rows which start from the margin nearest to that aperture are of course much shorter than those which start from the more distant margin (Figs. 7 and 8). There are however only a few lines of cilia that reach the mouth, these being the shorter ones, the others stop so as to leave the central part of the disk naked (Fig. 8.)

The cilia forming these rows are thick, short, slightly recurved, scarcely attenuated at their free extremity, and only beat for moments. Their length decreases regularly from the margin of the peristome to the inner extremity of the row.

Returning to the motor cilia and their relation to the cilia of the disk, it is found that the margin of the peristome is not simply rounded but rather denticulated, the teeth resembling those of an ordinary saw, one side of which is very long and nearly a tangent to the circumference, while the other is short and nearly follows the radius. All the teeth are turned in the direction towards which the rows of short thick cilia deviate; and each of the rows corresponds to one of the denticulations in such manner that it terminates at the base of the longer side of the denticulation.

The large motor cilia are implanted upon the longer margin of each denticulation. Hence they do not form a continuous circular or spiral line, but a broken line, the segments of which are only simple continuations of the rows of short cilia.

In other words all the cilia, whatever they may be, which garnish the disk, are implanted in accordance with about twenty parallel spiral lines. Each row commences tangentially to the margin of the disk by a certain number of motor cilia, then curves towards the centre, bearing short thick cilia, gradually diminishing from the periphery towards the centre.

The entrance to the mouth meets the surface of the disk obliquely, the pharynx being directed towards the left, at the same time gradually contracting (Figs. 7 and 8). By looking at the animal in profile (Fig. 7) it is easy to see that the pharynx is lodged in a pouch-like lateral projection of the body of the Infusorian. This projection is more strongly marked in certain species, and becomes very striking in meagre individuals when placed exactly in profile. A certain number of the rows of cilia of the disk (those, no doubt, which start from the margin of the peristome nearest to the mouth) may then be seen to descend into the pharynx, and there form a series of nearly straight parallel lines composed of extremely fine cilia. The actual margin of the mouth is furnished with tolerably stout and long cilia which beat energetically; but Professor Fol has not succeeded in ascertaining precisely what relation may exist between

these cilia and those just described. All the rest of the surface of the body of the species observed was smooth.

After briefly criticizing Claparède and Lachmann, and Stein's descriptions of the ciliation of the Tintinnodea, Professor Fol states, that on the surface of the disk, in the neighbourhood of the mouth, there is a slight crescentiform projection, which rises above the side on which the margin of the orifice forms an acute angle (see Fig. 8). Whether this projection is comparable to the part that Stein describes under the name of "forehead" is uncertain; but it has no relation, near or distant, with the disk of Vorticellina.

The nucleus is very difficult to see. It can hardly be discerned except in starved individuals. Whenever believed to be observed it appeared to be situated in the upper part of the body, and to present an oval form (Fig. 9). Sometimes Professor Fol believed he could distinguish a contractile vacuole in the inferior region of the body (Fig. 9).

The test is composed of a hard, slightly elastic material, which, however, breaks when the pressure is slightly increased. It resists acids even where tolerably concentrated, and presents no evolution of gas; therefore it is not an earthy carbonate. It burns away entirely at a dull red heat; hence it is not silica. It resists for a long time the action even of tolerably concentrated alkalies; consequently it is not a horny substance. There remains only chitine. The test generally presents two distinct layers, which, however, to all appearance, are of the same chemical composition. All the tests hitherto observed may be referred to three types, which seem at the first glance very distinctly marked—namely, smooth tests, tests garnished with adherent foreign particles, and latticed tests. However there are species which establish the transition between the smooth tests and the tests with adherent particles; and on the other hand, among the latticed tests, that which the author observed was continuous and only hollowed out by a number of small cavities on its outer surface. It was not perforated, which approximates it to certain smooth tests presenting patterns on their outer surface.

Professor Fol has not succeeded in observing the reproduction of these animals, though he frequently witnessed their conjugation. The presence of the test is not an obstacle to conjugation. The individuals do not quit their tests in order to unite; they amalgamate by the margin of the peristome. The point of union is absolutely constant; it is situated in the vicinity of the mouth, but a little to the left of the latter in such a way that two individuals in conjugation always form a perfectly symmetrical figure (Fig. 8). The union is tolerably extensive and very intimate, and lasts for several hours. During this time the copulated individuals cannot withdraw into their tests; their natation is however almost as rapid as that of the isolated individuals.

Turning next to the question of classification, Professor Fol traces the history of the group.

The genus *Tintinnus* was established by Otto F. Müller in 1776, and made to include a whole miscellaneous group of diverse forms.

Schrank in 1803, and afterwards Ehrenberg in 1838, circumscribed the genus, taking as its type the marine form *Tintinnus inquilinus* Schrank. Dujardin (1841) confounded the *Tintinni* with a very different genus (*Vaginicolæ*), and grouped together animals which had no real relationship. Claparède and Lachmann (1858) were the first to give any precise knowledge as to the structure of these Infusoria, and pointed out the important fact that the Tintinnodea have nothing comparable to the disk of the *Vorticellæ.* Then came Stein (1859-67) who, says Professor Fol, "by an incredible confusion, introduced disorder into the whole characteristic of the group." In fact this naturalist found a fresh-water Infusorian which he concluded was a true type of the genus *Tintinnus;* but which Professor Fol believes to have been a very different animal. Lastly, Haeckel (1873) described and figured various forms which he referred to two genera (*Dictyocysta* Ehr. and a new genus, *Codonella*).

Professor Fol proposes a provisional classification under the following genera, viz. *Tintinnus* Schrank, including as new species *T. ampulla* (Figs. 7 and 8) and *T. spiralis* (Fig. 9); *Coniocylis*, n. gen.; *Cyttarocylis*, n. gen. (*C. cassis* = *Dictyocysta cassis* Haeckel, Fig. 10). The name of *Dictyocysta* is reserved for the species in which the test is really perforated and reduced to a sort of open cage.

**Reticularian Rhizopoda.***—In the third part of his notes on these forms collected by the 'Challenger,' Mr. H. B. Brady reviews the classifications of the Foraminifera; pointing out that although the name itself hardly has its original meaning generally borne in mind, it has found far more general acceptance than any of the numerous other names that have been proposed; though the term "Rhizopoda Reticularia" (Carpenter) is perfectly appropriate. R. Hertwig is hardly justified in making the term Foraminifera synonymous with Carpenter's term Perforata, for the former does not apply to the holes in the test, but to the orifices by which the different chambers communicate with one another.

The new scheme of classification now proposed does not take the texture of the test as a primary distinction, but uses it in a modified way. There are nine groups, with four families:—(A) Test imperforate, chitinous: *Gromidæ.* (B) Test imperforate, normally porcellanous, &c.: *Miliolidæ.* (C) Test invariably arenaceous: *Astrorhizidæ*, *Lituolidæ*, *Parkeridæ.* (D) Tests of the larger species arenaceous, either with or without a perforate calcareous basis; smaller forms hyaline and conspicuously perforated: *Textularidæ.* (E) Test calcareous, finely perforate: *Chilostomellidæ*, *Lagenidæ.* (F) Test calcareous, generally very coarsely perforated, no trace of canal-system: *Globigerinidæ.* (G) Test coarsely perforate, a few of the higher forms with double chamber-walls and interseptal canals: *Rotalidæ.* (H) Test very finely tubulated; all the higher types possessing a system of interseptal canals of greater or less complexity: *Nummulinidæ.* More than one hundred new species are described. The "Notes" conclude with one on "Biloculina-mud."

* Quart. Journ. Micr. Sci., xxi. (1881) pp. 31–72.

**Protozoa Parasitic in Man and the Diseases to which they give rise.**—In the second edition of R. Leuckart's well-known work* on parasites we find an account of the Protozoa which inhabit man, which is far more detailed than that of the first edition, and is combined with an admirable exposition of the relations of the general structure and the development of Protozoa generally, and specially of the parasitic forms. The section embracing the Protozoa includes no less than 113 pages, and numerous original observations made by the author are contained in it. The Schizomycetes receive but brief notice, although the author "recognizes in their characters scarcely a single reason for separating them from the Protozoa." As *Protozoa* proper, the classes of the *Rhizopoda*, *Gregarinida*, and *Infusoria* receive full attention; hence it may be seen that Leuckart attributes to the *Gregarinæ*, including the *Psorospermiæ*, the importance of an independent class of the Protozoa, for which he proposes at the same time the new designation *Sporozoa.*

In the following account we shall limit ourselves to a short notice of the parasites of man, which form the proper object of the work, and only notice by the way the author's general ideas with regard to the groups under review. The polythalamous forms seem to the author to owe their origin to an asexual form of reproduction of the *Rhizopoda*, if an expression of this kind is permissible, so that in accordance with this view they may be set down as resembling the colonies of the *Heliozoa* and *Radiolaria.* This interpretation appears, however, to be by no means a natural one, for the relations of the nucleus, as set forth by R. Hertwig and F. E. Schulze, are not to be reconciled with it.

The *Rhizopoda* are represented as parasites of man only by the protean genus *Amœba*, and but one species belonging to the group is satisfactorily known, viz. *A. coli* Lösch, which was found in large quantities in the stools of a Russian peasant who suffered from inflammation of the large intestine. Further observations render it probable that the occurrence of this form is not so rare as has been supposed. Whether we have here to do with a special parasitic species or only with an occasional parasite—a question which, of course, owing to the protean character of most of the so-called species of *Amœba* hitherto described, can hardly be settled—Leuckart leaves undetermined, but remarks on the resemblance which this form bears to that described by Von Mereschkowsky as *A. Jelaginia.* Leuckart considers that Lösch's experiments on dogs prove the power of these Amœbæ, when occurring in large quantities on the mucous membrane of the intestine, to cause hyperæmia and increased secretion of mucus and even extensive inflammation.

Of the *Gregarinæ* and their allies, the *Sporozoa* of his classification, Leuckart gives a very full account; they are treated of in their general relations, both of organization and development, in so far as these have been made known by the older and more recent investiga-

* 2nd edition, vol. i. part 1 (8vo. Leipzig and Heidelberg, 1879). Cf. Zool. Jahresber. Naples, I. (for 1879) pp. 117–21. Abstract with critical remarks by Prof. Bütschli.

tions of Aimé Schneider, E. van Beneden, &c. The views of Gabriel are not noticed. In particular, the so-called Psorospermiæ, and among these the "oval Psorospermiæ," which occur not uncommonly in mammals and sometimes even in man, are noticed with especial care. Again, all that has been known since the time of Joh. Müller with regard to the "psorospermia-sacs" of fish and frogs is given at considerable length, and their differences from, together with the points connecting them with the true Gregarinæ, are brought into prominence.

The egg-shaped Psorospermiæ, observed in 1855 by Kloss in Invertebrata (garden snail), and studied more minutely in the cuttle-fish, Leuckart denominates *Coccidia*, and mentions the well-known parasite of the liver of man and the rabbit under the name *Coccidium oviforme*. It is not quite clear whether the author includes under this generic title *Coccidium* those parasites also of the Invertebrata and of some mammals, which have been mentioned in this connection, and have been designated by A. Schneider as *Klossia*, *Benedenia*, and *Eimeria*, for these names are also occasionally introduced. The forms belonging to the genus *Coccidium* are characterized as devoid of covering, and as inhabiting epithelial cells in their young condition, but as becoming covered with a shell after growth is ended. In this condition they emerge from the epithelial cells and in part abandon their host. Within the shell the body developes into from one to a large number of spores, which in their turn develope bacillar or spiral embryonic forms within themselves; a part, however, of the original granular contents of the spore generally persists in the form of the so-called granular mass.

We pass over the carefully elaborated views of former observers as to the nature of the organisms in question, with their manifold divergences of opinion, and from the detailed description of the organization and development of *Coccidium oviforme* we select the following points. The two forms of *Coccidia* which are found free in the so-called psorospermia-balls of the rabbit, namely, the more slender form with its contents entirely filling the test, and the more capacious form with contents contracted into a globular mass, are brought into harmony with one another as different stages of development, that is, the former represents the earlier condition, which produces a fresh and capacious shell underneath the original one, which is ultimately lost, and which developes into the second form by contraction of the contents into a ball. The bulky form is distinguished further by the existence of an opening resembling a micropyle at the pointed pole of the test and by the presence of a pale sphere in the globularly contracted contents, which, however, Leuckart is unable to recognize as a nucleus.

With regard to the constitution of the psorospermia-balls taken as wholes, they are the result of the widening of the bile-ducts and the union of the walls across their lumina, the connective tissue in their vicinity undergoing considerable proliferation. Various stages of development point to the origin in this manner of the "balls" or "knots" by fusion of neighbouring bile-ducts. The development of

the Coccidia goes on in this case also in the bile-ducts which become converted into knots, as may be determined by careful examination of sections. The earliest stages of development which are met with in the epithelial cells are roundish non-cuticulated masses of protoplasm ·009 to ·01 mm. in diameter. Although in most cases but one intruder is to be found in each epithelial cell, two are not at all uncommon, and from five to six are occasionally observed. By the development of the Coccidia and the active multiplication of their cells the epithelium is greatly modified, for the cells become changed into roundish mulberry-shaped balls, which lie in a thick layer on the connective-tissue wall of the cavity of the knot.

The Coccidia become transformed also into the slender encapsuled forms described above and found within the epithelial cells, and after passing into a free condition in the interior of the knots, undergo transformation into the ventricose stage. No further development within the host has been observed in the case of *Coccidium oviforme*, but it may be assumed with probability that a certain number of this parasite at this stage of development find their way to the exterior by the gall- and bile-duct and the intestine. Since the investigations of Kauffmann it has been known that Coccidia undergo further development in water apart from the body. This development appears to require several weeks or months for its completion, at any rate in the case of the Coccidia of the liver. This further development or formation of spores (which may also be termed formation of Psorospermiæ, seeing that these spores are comparable only with the true Psorospermiæ) is effected by division of the contents of the Coccidium into four balls; it is doubtful whether this is the result of successive dichotomous divisions or of a division into four at one stroke. Each of the four segmentation spheres thus produced excretes a delicate investing envelope, and forms besides a C-shaped rod which lies at the periphery, accompanied by the remains of the granular mass (comparable to the "Nucléus de reliquat" of Schneider).

Coccidia which have reached this developmental stage are regarded by Leuckart as fitted to cause infection when taken up by their proper host; from analogy afforded by kindred animals, he looks on the C-shaped rods as the true germs, but endeavours to explain the further development of the spores observed by Waldenburg and Rivolta as phenomena of decomposition. Neither the spores nor their C-shaped germs were ever observed to leave the body of the host.

Consideration of the *Coccidia* (*Eimeria* A. Schneider), described by Eimer from the intestine of the common mouse leads Leuckart to the conclusion that we have here a form which is probably specifically distinct from *Coccidium oviforme*, and that in all probability the intestinal species observed in other Mammalia do not agree specifically with those found in the liver; he therefore proposes the name *Cocc. perforans* for those of the intestine. Leuckart is enabled by his own investigations to add two cases of the occurrence of *C. oviforme* in man to those already known. The rabbit is un-

doubtedly the agent which transmits the *Coccidia* of the liver; dogs and cats must be included with this animal as harbouring those of the intestine.

The alleged discovery by Lindemann of Psorospermiæ in the human kidneys is regarded with great doubt by Leuckart; and the Gregarinæ of the hair described by that observer are allowed no claim to serious notice.

In dealing with the Infusoria, a general account is given of their organization and developmental history. The Flagellata are the subjects of a special description; they are made the 1st Order of the Infusoria.

Leuckart has been unable to notice fully the nine species described by Steinberg, from the genera *Monas*, *Bodo*, and *Cercomonas*, found in the enamel of the human teeth, owing to the inaccessibility of the work referred to; uncertainty also prevails with regard to *Bodo saltans* and *Monas crepusculum*, discovered by Wedl in foul abscesses; also as to the *Bodo urinarius* of Hassall. On the other hand, there is more certainty about *Cercomonas intestinalis* Lambl. This form was first observed by Davaine in the stools of cholera and typhus patients, and was afterwards found in those accompanying the diarrhœic condition, and was identified by Lambl in the liquid of a large Echinococcus-cyst in the liver. How far this parasite is to be connected as an originating agent with those complaints of the intestine which it usually accompanies appears to be an open question; but it is probably not to be regarded as the proper originator, but as contributing by its abundant development to the aggravation of the malady in cases where it has found a favourable field for its increase. With respect to the organization of the genus *Trichomonas*, Leuckart inclines to the explanation that—at any rate, in the case of *T. batrachorum*—a genuine undulating fringe occurs, in opposition to Stein's explanation of what appears to be of this nature.

An especial addition is made by Leuckart to our knowledge of *Trichomonas vaginalis.* To the genus *Trichomonas* he adds the forms described as *Cercomonas* by Marchand and Zunker from the stools of typhus patients or subjects suffering from severe enteric affections; it is termed *T. intestinalis* Leuckart. Its two anterior cilia might well have been overlooked by the observers just mentioned. In its pathological and clinical relations this form ranks with *Cercomonas intestinalis.*

Of the Ciliata certain forms, such as *Colpoda cucullus* and *Vorticella*, appear to develope occasionally in foul wounds and abscesses; the *Bursaria* described from a similar locality by Wedl is considered by Leuckart as possibly referable to *Glaucoma scintillans* Ehr. Thus the only truly parasitic Ciliate left is the well-known *Balantidium coli* Malmst.

Observations of the occurrence of this parasite have been largely multiplied of late, but all the instances known are confined to Sweden and the Russian Baltic provinces, so that, considering the probably indisputable fact of the transmission of this parasite by the pig, of which it is a constant inhabitant, Leuckart is most likely right in

tracing the fact of its appearance in these countries to certain habits of living which facilitate the transference of the parasite from the pig to man. In his description of the structure of this Infusorian, he gives an improved account of the peristome, mouth, œsophagus, and nucleus, but could not find the nucleolus mentioned by Wising. The conjugation observed by Wising is detailed, and a corrected account is given of the process of fission, which goes on as described by Stein of *B. entozoon*. The transmission of the parasite takes place in the encysted state, as may be inferred with probability from analogy with the parasitic Opalinæ as well as by direct observation, at any rate of the specimens found in the pig; hence the process of infection of man by the pig may be readily concluded. The pathological importance of *Balantidium* may probably be set down as similar to that already shown to hold in the case of the Amœbæ and Monads of the intestine.

**Parasitic Protozoa, especially those of Man.***—The following notice relates to the parasitic Protozoa observed by Grassi during a not very lengthy period of investigation (July to October, 1879). The chief locality was Rovellasca in Lombardy. The Rhizopoda were represented by a Moneron of doubtful character which was found in blood (of what animal not stated), extremely seldom, and by a number of *Amœbæ*. Among the latter, that interesting and not unimportant inhabitant of the human intestine, *A. coli* of Lösch, is said to have been noticed in no less than six instances. A similar form was found in the colon of the mouse, and named *A. muris* n. sp. Besides these a species named *A. dentalis* Grassi n. sp. (probably identical with *A. buccalis* Steinberg) was observed in the human mouth in three cases; it is stated to closely resemble *A. coli*. The *Amœbæ* of the frog's intestine, already repeatedly studied, were included by Grassi in his investigations, and named by him *A. ranarum* n. sp. A new *Coccidium* (*C. Rivolta* n. sp.) was met with in the colon of the cat. The establishment of this new species is justified chiefly by its development; the granular contents (which, it must be observed, probably belong to an encysted form) divide into two roundish spores, each of which produces four semilunar Moneran germs (the sickle-shaped bodies of Schneider), and a nucléus de reliquat.

A very considerable series of Flagellata are also brought forward, for which the author proposes a new division into genera, considering those already in use, based chiefly on the number and structure of the flagella, not to be thoroughly practical, owing to the difficulty of determining these characters. He proposes the name *Mono-cercomonas* for a genus characterized by the possession of a simple caudal appendage, and divisible into four subgenera.

Subgenus 1. *Monocercomonas* s. str. Naked.—*M. hominis* (= *Cercomonas hominis* Dav.? *C. intestinalis* Lamb.? *Trichomonas intestinalis* (Lamb.) Leuck.). This form is described at length, and came under observation in no less than 100 cases. The author endeavours to

* Gazz. Med. Ital. Lomb., 1879, No. 45. Cf. Zool. Jahresber. Naples, I. (for 1879) pp. 121–3. Abstract with critical remarks by Prof. Bütschli.

refer the undulatory motion, which may be seen in a number of individuals, as also in *Trichomonas* and *Hexamitus*, to a flagellum attached to the anterior end of the body and directed backwards. The normal number of flagella at the anterior end is four, but they frequently adhere throughout their entire length. A mouth-opening is placed rather to the side of this end of the body. With regard to the phenomena of development, the author does not consider it probable that the caudal appendage, after swelling considerably, sometimes becomes detached and gives rise to a new individual. The organisms die at 55° C. Patients affected by the parasites manifest acute or subacute diarrhœa. Grassi is unable to regard this monad as the origin of the complaint, but considers its appearance merely a circumstance attendant on the diarrhœa which is produced by other causes; in this connection it appears to him an important fact that the liquid of the fæces forms one of the conditions of the existence of the organism. He considers the possibility of its occurrence in healthy subjects as not at present demonstrable. The remedy applied was a solution of ipecacuanha ($1\frac{1}{2}$ grams in 100 of water), but the ipecacuanha does not act fatally on the monads. No diarrhœa is set up in dogs by administering to them infected fæces. Other forms belonging to the subgenus are mentioned as having been studied, viz. *M. Caviæ* Gr. sp. (= *Trichom. caviæ* Dav.?), *M. coronellæ* n. sp. (= *Cercomonas colubrorum* Ham.?), *M. anatis* n. sp., *M. batrachorum* n. sp. (= *Cercomonas intestinalis* Ehr.? *Trichomonas batrachorum* Per.?). In the last-named monad, also, the undulatory movement is explained as due, not to a vibrating fringe or a series of cilia, but to a large flagellum placed at the anterior end. *M. muris* n. sp. has but one flagellum at this part. *M. lacertæ viridis* is another new species.

The genus *Trichomonas* is made by Grassi a subgenus of *Monocercomonas* and characterized as pilose, and thus is quite differently constituted from the customary method. *T. melolonthæ* n. sp. is shortly described, but from its clothing of hair-like, immobile processes appears to bear a closer relation to *Mallomonas* Perty. Although more than 100 women were examined, *Trichomonas vaginalis* Donn. was not met with. Monads were only once found in the mouth.

*Retortomonas*, a third subgenus of *Monocercomonas*, is characterized by its retort-like shape, and a species, *R. gryllotalpæ*, is shortly described from *Gryllotalpa*.

The fourth subgenus, *Schedoacercomonas*, "similarly without caudal appendage," appears with four species, *S. gryllotalpæ*, *S. melolonthæ*, *S. caviæ* nn. spp., and *S. muscæ domesticæ* (= *Cercomonas muscæ domesticæ* Barnett). The genus *Dicercomonas* is distinguished from *Monocercomonas* by the bifurcate caudal appendage, and is divided into two subgenera, *Monomorphus* "appearing in a single form," and *Dimorphus* "appearing in a double form." (From the description of *D. muris*, the double form appears to mean nothing more than the difference in form which the monad assumes when seen from different sides). *Monomorphus* is based on the well-known *Hexamita ranarum* Duj., which is said probably to possess six anterior flagella, and in which

the oscillating fringe described by Stein is probably caused by two flagella.

*Dimorphus muris* n. sp. is described more fully.

Of parasitic ciliate Infusoria were observed *Trichodina tritonis* n. sp., from the intestines of *Triton* (probably identical with the *Trichodina* known to inhabit the bladder of the Tritons), *Balantidium coli* Stein (in the pig), *Plagiotoma cordiformis* and *lumbrici*, *Opalina ranarum*, *dimidiata*, and *trigona*.

**Psorosperms of Fishes.***—Professor O. Bütschli here deals with the *Myxosporidia*, or fish-psorosperms, which are so widely distributed as parasites in fishes. They appear, at any rate in the case of Cyprinoids, to especially affect the gills, where they have the appearance of small white pustules; they undergo their development in the layer of connective tissue which separates the two epidermal layers of the gill-lamella, and they come therefore into very close contact with a rich supply of capillary vessels. The myxosporidium, when closely examined, is found to be a more or less considerable mass of protoplasm, which always contains a large number of spores at various stages in development. There is no difference between an ecto- and an endoplasm. The author was able to satisfy himself as to the existence of a distinct investment, which did not, however, belong to the category of ordinary envelopes, but was of a plasmatic nature, for it was clear, and finely granular, and had a number of small nuclei imbedded in it.

Contrary to the opinions of some investigators, Dr. Bütschli states that the protoplasm is thickly interspersed with a very large number of small, though distinct, nuclei.

The covering or shell of the spores has a remarkable resistance to reagents; it contains a cloudy protoplasmic substance in its posterior portion, while the anterior is largely occupied by the so-called polar corpuscles. These last are capsules with a pretty thick wall, within which there is rolled up a long pale filament, so that the whole structure has a very striking resemblance to an urticating capsule.

After discussing the way in which this is ejected, the author directs attention to the striking fact that there is certainly a nucleus in the plasmatic contents of the spores. With regard to the general characters of the spore-formation, it is to be noted that their development is not confined to any special adult stage of the myxosporidium, but that they are to be found at all ages, and in the most different forms. The ripe spores have an elongated-spindle shape, the envelope is distinct and pretty thick, and often striated.

**Bütschli's 'Protozoa.'**—In the 8th and 9th parts of this work Professor O. Bütschli deals with the geographical distribution of the Rhizopoda, and with their palæontological history (the account of which is communicated by C. Schwager). He then passes to the Heliozoa, and quotes the titles of fifty-one papers on this small group; the forms which compose it are divided into the several subdivisions of Aphrothoraca, Chlamydophora, Chalathoraca, and

* Zeitschr. f. wiss. Zool., xxxv. (1881) pp. 629–51 (1 pl.).

Desmothoraca. With regard to the multinuclear condition of various forms, we find just the same conditions as among the Rhizopoda; a large number have, so far as yet known, only one nucleus; others, such as *Vampyrella* sp., have three, *Nuclearia delicatula* has five or six, and *Actinosphærium* possesses 100 to 200 nuclei, and (according to the observations of Carter) may have 300 to 400. In these forms the nucleus has a definite position within the endosarc. There may be a number of nucleoli in the nucleus. The characters of the pseudopodia of *Actinosphærium* are especially insisted on, and it is pointed out that, just as in the fine pseudopodia of the Rhizopoda, streaming movements are to be seen in these processes. The phenomena of reproduction are carefully described, and the difficulties as to the explanation of the process of conjugation examined.

## BOTANY.

### A. GENERAL, including Embryology and Histology of the Phanerogamia.

**Development of the Embryo of Grasses.***—C. Nörner has closely investigated this subject, especially in the cases of the common cereals, barley, wheat, rye, and oats. The fertilized ovum (oosphere) is in all cases first divided into three segments by two cell-walls formed rapidly one after the other. But according to the position of these segment-walls, three different types of development may be distinguished. In the first type, the two segment-walls are parallel, and are found in basipetal succession; and a three-celled embryo is thus the starting-point for further cell-divisions. In the second type the second segment-wall is not parallel to the first, but meets it at an acute angle; while in the third the first wall is oblique to the longitudinal axis of the embryo, the second again meeting the first at an acute angle, the size of which varies greatly. These two last types of development had hitherto been almost overlooked; but all three occur in the development of the embryo even of the same species. The further course of development is traced by the author in detail in a number of instances.

The best mode of treatment of the embryo of grasses was found by the author to be as follows:—The ovary was laid for a considerable time in absolute alcohol. Shortly before being examined it was taken out and placed in a mixture of alcohol and distilled water, to prevent its becoming too hard for section. It was then taken between the finger and thumb, and sections carefully made with the razor in the longitudinal direction; these were laid on the slide, and a drop of very dilute potash added. The embryo-sac or the section which contained the embryo was next taken out, and placed in a small quantity of distilled water on a fresh slide. The embryo was then carefully removed from the endosperm with a needle under the

* Flora, lxiv. (1881) pp. 241–51, 257–66, 273–84 (4 pls.).

dissecting Microscope. As a rule, it was then sufficiently transparent. This method is especially to be recommended for examining the younger stages of development; older embryos require a longer treatment with concentrated potash-solution, and a further addition of alcohol or dilute glycerin. If the embryo has become too clear, dilute hydrochloric acid may be added, and the preparation then coloured by hæmatoxylin or solution of eosin, with final addition of dilute glycerin. Ammonia may also be used, alone or in conjunction with potash-solution.

Collenchyma.*—E. Giltay states that, although in some cases collenchyma may consist of a procambial or pseudo-procambial prosenchymatous tissue, in others its gradual development may be followed out from a parenchymatous tissue. The original parenchymatous cell may acquire, during its elongation, a more or less perfectly prosenchymatous form; at first the collenchymatous thickenings make their appearance only at the corners, subsequently, however, affecting the whole cell-wall. When, as is more often the case, there is also lignification, a more or less typical sclerenchymatous fibre becomes differentiated, independently of the more or less prosenchymatous nature of the cell in the stage preceding lignification. The cell may remain permanently at any of these stages of development.

Very slight collenchymatous thickenings are but of small importance to the cell. Although no sharp line of demarcation can be drawn, in this category must be included the collenchymatous thickenings which often occur in parenchymatous cells with large intercellular spaces, generally clothing the intercellular space only; the parenchymatous cells with slight collenchymatous thickenings which are found especially on those parts of the bark that are adjacent to fissures; and perhaps also in some cases the collenchymatous epidermis and the collenchymatous bast.

What must be regarded as typical collenchyma almost always occurs near the periphery of the organ, imparting to it its firmness and elasticity. The collenchyma does not only, like sclerenchyma, carry on as a whole a contest with the assimilating tissue; its cells are also, so to speak, at war with chlorophyll, which attempts to enter them, causing them to revert to the condition of unthickened parenchymatous cells bordering on intercellular spaces, in which cells the chlorophyll best comes into play. A very sharp demarcation is frequently displayed between the thin-walled chlorophyllaceous cells of the cortical parenchyma and the collenchymatous cells which they surround, and which are completely devoid of chlorophyll. In the transitional forms between these last and assimilating cells, we find slight thickenings and intercellular spaces. These transitions are especially well seen in plants with a typical sub-epidermal ring of collenchyma, in which some cells which contain a small amount of chlorophyll indicate a connection between the green bark and the stomata. From these instances it may be seen that in general the development of chlorophyll and of collenchyma stand in inverse proportion to one another

* Bot. Ztg., xxxix. (1881) pp. 153–9.

A typical collenchymatous cell can only contain much chlorophyll when, at least at its corners, it borders a sufficiently large intercellular space; large intercellular spaces sometimes arising in a collenchymatous tissue for the purpose of assimilation.

Except in the comparatively few cases in which collenchyma occurs in bundles, it is usually disposed in peripheral discs or in a cylinder. It occasionally reaches the epidermis, and then becomes more or less chlorophyllaceous; in other cases it is entirely driven back from the epidermis, and then forms, on transverse section, an unbroken ring, giving the plant its greatest possible elasticity.

When the corners of the subepidermal collenchymatous cells are considerably thickened, this thickening often extends only to the peripheral and not to the radial walls of the cells. If, in this case, the cells are of nearly equal size, and their arrangement regular, so that the thickened spots of the walls are in apposition, the collenchymatous substance then forms two or more concentric cylinders.

The mechanical function of collenchyma is not confined to mature organs, but is exercised also in those which are still growing, forming the "stereome" capable of extension. In the motile cushions of many leaves the stereome, then consisting partially or entirely of sclerenchyma, occupies a central position. It also occurs, more or less strongly developed, in growing tendrils, and in the twining internodes of climbing plants, as in monocotyledons, where it is otherwise rare.

Collenchyma occupies, then, a position second only to the sclerenchyma in facilitating elasticity, this being largely dependent on its hydrostatic properties.

The writer considers collenchyma, in its typical form, fully entitled to be regarded as a distinct kind of tissue, not only because it is clearly distinguished from the most nearly related kinds by its anatomical peculiarities, but because its cells unite more fully than in any other tissue the two antagonistic characters—the tendency to decided thickening of the walls, and at the same time the tendency to be very loosely united with one another.

**Chemical Nature of the Cell-nucleus.***—E. Zacharias has determined the nucleus of the cells of plants to consist of a peculiar substance differing chemically from the surrounding protoplasm, and identical with the *nucleine*, of which Miescher states the nucleus to be composed in the animal kingdom, and to which he assigns the formula $C_{29}H_{49}N_9P_3O_{22}$ in the case of animal spermatozoa. The properties of nucleine are as follows:—It is attacked only with great difficulty by the gastric juice; it is nearly insoluble in water, quite so in dilute mineral acids, but easily soluble even in very dilute solutions of caustic alkalies, ammonia, concentrated nitric acid, and fuming sulphuric acid. In the freshly precipitated condition it is soluble in soda and sodium phosphate; solution of sodium chloride transforms it into a swollen, coherent, tough jelly; iodine colours it

* Bot. Ztg., xxxix. (1881) pp. 169–76.

yellow, Millon's reagent red. These solutions and the presence of phosphorus distinguish nucleine from other albuminoids.

Zacharias demonstrated these reactions in nuclei obtained from the epidermal cells of *Tradescantia virginica*, and from the parenchyma of young leaves and stems of *Ranunculus Lingua*. If a fresh *Tradescantia* cell is treated with artificial gastric juice, the delicate punctation of the nucleus becomes at first somewhat more distinct, its volume being slightly reduced; it then becomes completely homogeneous, and presents the appearance of a drop of oil. But it soon begins to increase again rapidly in volume, loses its brightness, and becomes frothy; and finally, without again shrinking perceptibly, has a sharp outline, is frothy, yellow, and strongly refractive. As soon as the nucleus increases in size and becomes homogeneous, the starch-producers swell up rapidly and disappear. The protoplasm of the cell becomes at the same time completely or partially frothy, the bubbles being filled with a clear yellow fluid. Finally, the bubbles burst, and the cell-protoplasm disappears; the nucleus being enclosed in a very delicate colourless folded pellicle, of somewhat swollen appearance, the remains of the parietal layer, the threads, and the nuclear disk. After longer treatment with gastric juice, this residue of the protoplasm loses its swollen appearance, and forms a somewhat shining pellicle round the nucleus, which undergoes no further change.

**Metastasis in the Vegetable Organism.***—W. Detmer defines metastasis (*Stoffwechselprocesse*) as comprising those processes by means of which organic compounds already present in the organism are transformed into new organic compounds, or are completely destroyed. The metastatic processes in the cells of plants may be associated with the absorption of oxygen and evolution of carbonic acid, with the absorption of oxygen alone, with the evolution of carbonic acid alone, or finally, even with the evolution of oxygen. These last can, of course, take place only in cells that contain chlorophyll, and only under the influence of light, and are hence liable to be confounded with processes of assimilation. But this last term should, according to the author, be confined to processes which take place at the expense of inorganic substances, such as carbonic acid and water, resulting in the production of organic compounds.

With regard to the process of respiration, Detmer distinguishes the following four kinds:—

1. *Normal respiration.* This term is applied to the process which is connected with the absorption of oxygen and evolution of carbonic acid, the volume of gas eliminated being equal to that of the gas absorbed.

2. *Vinculation-respiration.* This takes place in the case of the oil of oily seeds in the early stages of germination, the absorption of oxygen not being accompanied by any evolution of carbonic acid.

3. *Internal respiration.* This process is associated with the evolution of carbonic acid, but not with the absorption of free oxygen,

* Jahrb. f. wiss. Bot., xii. (1881) pp. 237–87.

as, for example, when yeast produces carbonic acid without the presence of free oxygen, decomposing the sugar with production of alcohol.

4. *Insulation-respiration.* This is a process of evolution of oxygen, which takes place in the decomposition of vegetable acids, and is possible only under the influence of light.

The following four kinds of metastasis may also be distinguished:—

1. *Dissociation* includes those processes which result in a definite decomposition of any substance into several compounds, as when the proteids of protoplasm are decomposed into a nitrogenous and a non-nitrogenous substance.

2. *Association.* This takes place when certain nitrogenous and non-nitrogenous substances unite to form proteids.

3. *Decomposition.* A typical instance of this occurs in the disappearance of starch in the germination of seeds; it is always associated with normal respiration.

4. *Metamorphosis.* This is not connected with the complete decomposition of organic compounds, the resulting organic compounds being nearly related to those from which they are derived; as, for example, when dextrine is converted into glucose. No process of respiration, except the second, can take place in connection with metamorphosis, but it includes certain processes of oxidation connected with the fatty acids.

The substances which are employed in the building up of organized vegetable structures, such as cellulose, starch-grains, proteids, &c., whether directly or in connection with metastatic processes, may be termed *plastic substances.* To those metastatic processes which yield products that have no direct relation to the processes of growth in the vegetable organism, the term *degradation-products* may be applied. Mucilage is, for instance, a degradation-product of cellulose and starch.

The remainder of the paper is occupied with a discussion on the behaviour of proteids in metastasis, and of the phenomena of respiration and fermentation. The latter the author regards as a true process of dissociation, not necessarily connected with the presence of a so-called "ferment."

**Hydrostatic Tension as a Cause of Movements of the Sap and of various Organs.***—The formation of cushions at ligatures and at spots of the stem which had been decorticated, is usually ascribed to the action of a descending sap. M. A. Barthélemy has been unable to obtain direct evidence of the existence of such a descending current; the actual facts point rather to a lateral force. The ascending current of sap is determined by the suction of the roots, and by the evaporation and fixation of water on the surfaces of the leaves; the reverse movements being due to the cessation of evaporation and the reaction which results.

The phenomena of heliotropism, and the movements of the leaves

* Comptes Rendus, xcii. (1881) pp. 1121–3.

of the sensitive plant, M. Barthélemy believes to be capable of explanation on the same general principle—a variation of tension due to the action of the sun. In short, the movements of fluids within the plant and those of flexible organs are alike dependent on variations in the hydrostatic tension, under the influence of the suction of the roots, and the reaction of the foliaceous extremities.

**Poulsen's Botanical Micro-Chemistry.***—The German edition of this work, by C. Müller, is not merely a translation, but is enriched by numerous additions and corrections by the editor.

After an index to the most important works on micro-chemistry, the text of the book is divided into two sections. The first treats of micro-chemical reagents and their use; the second of vegetable substances and the methods of diagnosis. This division greatly increases the usefulness of the work for students. If, for example, it is required to gain information on the use of chlor-iodide of zinc, the subject is looked up in the first section. If, on the other hand, information is desired on the presence or absence of an "intercellular substance" in any tissue, the application of reagents to determine this point will be found in the second section. In the same manner, the student can at once refer to all that is known about Schultze's maceration, Hanstein's method of rendering tissues transparent, Trommer's sugar-test, &c. &c.

## B. CRYPTOGAMIA.

### Muscineæ.

**Hybrid Moss.**†—In some mosses from Oporto, consisting of *Leptotrichum subulatum*, intermingled with *Pleuridium subulatum*, M. Venturi detected one plant that seemed to combine the characters of both, and which he considers to be their hybrid.

The form of the capsule corresponded to that of *L. subulatum*, although it was a little shorter; but the much smaller operculum was here so attached that on cutting the fruit longitudinally through the middle a diversity of tissue was clearly visible at the spot where the conjunction of the operculum ought to be; but it was only torn with difficulty, just as, in the capsule of *Pleuridium*, the part corresponding to the lid is not easily separated from the rest of the capsule. The transition from the areolation of the lid to the wall of the capsule was insensible, without a trace of peristome, as in most mosses designated *Cleistocarpi*.

The pedicel was only twice as long as the capsule, so that the perichætial leaves were longer than the pedicel together with the capsule. The vaginula was, nevertheless, cylindrical like that of *L. subulatum*, and the antheridia disposed as in *Pleuridium*, only more consistent, and in this respect resembling the antheridia of *L. subulatum*.

* Poulsen, V. A., 'Botanische Mikrochemie. Eine Ableitung zu phytohistologischen Untersuch. zum Gebrauch für Studirende ausgearbeitet. Aus dem Dänischen unter Mitwirkung des Verfassers übersetzt von Carl Müller. xvi. und 83 pp. (8vo, Cassel, 1881.)

† Rev. Bryolog., viii. (1881) pp. 20–2.

The lower leaves were in form like those of *Leptotrichum*, with the nerve occupying one-third of the width of the base; but the upper leaves, and especially the perichætial, had a much narrower nerve, disappearing completely in the minute leaf, and the subulated portion passing gradually into the vaginal.

The areolation of the leaves was, in the lower ones, like that in *L. subulatum*; in the perichætial it was, on the contrary, like that in *P. subulatum*.

M. Venturi considers the fact of this hybridation between two genera placed in two different classes a very important argument for finally abandoning the entirely artificial and in no way natural classification of the Musci cleistocarpi, and for placing the genera of this class in divisions founded on their anatomical characters.

European Sphagnaceæ.†—In his recent work on the European bog-mosses, C. Warnstoff proposes a somewhat different system of classification from those hitherto adopted. Believing that no single character can be safely used, even when constant, he lays less stress than has hitherto been done on the peculiarities of the inflorescence, and draws his chief distinguishing marks from various characters, the form of the stem-leaves, the number of the cortical layers of the stem, the presence or absence of fibres or pores in the stem-leaves, &c. From these characters he draws up the following scheme of the European species:—

A. No spiral fibres in the cortex of the branches; branch-leaves always distinctly toothed at the apex.
- *a*. Stem-leaves always broadest at the base; more or less distinctly narrowed at the apex.
  - *α*. Margin of the branch-leaves revolute at the apex only.
    1. Cortex of 3–4 layers; cells moderately large.
       - * Tuft of branches united into 3–5 branchlets. *S. acutifolium* Ehr.
       - ** Tuft of branches united into 7–13 branchlets. *S. Wulfianum* Girg.
    2. Cortex of 1–2 layers; cells very narrow. *S. variabile* Warnst.
  - *β*. Margin of the branch-leaves broader, often revolute to the base.
    1. Stem-leaves small or large, always almost tongue-shaped.
       - * Stem-leaves with a narrow border; border not much broader below. *S. cavifolium* Warnst.
       - ** Stem-leaves with a wide border; border much broader below. *S. molluscum* Bruch.
    2. Stem-leaves always very small, triangular, rounded at the apex, or broadly fringed. *S. rigidum* Schpr.
- *b*. Stem-leaves always broadest at the middle, narrower at the base and apex. *S. molle* Sulliv.

† 'Die Europäische Torfmoose,' von C. Warnstoff (Berlin, 1881). See Flora, lxiv. (1881) p. 284.

*c*. Stem-leaves always broadest at the upper part; only evidently narrowed below.
  1. Stem-leaves fringed only at the broad apex; cortex of 3–4 layers. *S. Lindbergii* Schpr.
  2. Stem-leaves fringed not only at the broad apex, but also on the margins low down; cortex of two layers. *S. fimbriatum* Wils.

*d*. Stem-leaves of equal breadth above and below; hence tongue-shaped.
  1. Branch-leaves ovate-lanceolate, toothed at the narrow apex.
     * Cortex in 3–4 layers, porous. *S. Girgensohnii* Russ.
     ** Cortex in 2–3 layers, not porous. *S. teres* Angstr.
  2. Branch-leaves broadly oval (almost as in *S. cymbifolium*), toothed at the broad apex. *S. Angströmii* Hartm.

B. Spiral fibres in the cortex of the branches; branch-leaves always very finely dentate-ciliate at the apex and on the margin lower down. *S. cymbifolium* Ehr.

### Characeæ.

**Genevan Characeæ.**†—In his synopsis of the Characeæ of the neighbourhood of Geneva, J. Müller retains the family as a distinct group, associating them with the Muscineæ under the term Bryanthogamæ. He regards them as constituting a single family, composed of two genera only, *Chara* and *Nitella*. A number of new forms are described.

*Nitella mucronata* Kütz. is regarded as a variety of *N. flabellata* Braun. Of *N. gracilis* a new form $\gamma$ *maxima* is described; and of *N. intricata* a $\beta$ *tenuis*.

In the genus *Chara* descriptions are given of a large number of new forms belonging to the species *C. ceratophylla* Wallr., *contraria* Braun, *fœtida* Braun, *hispida* Braun, *aspera* Willd., and *fragilis* Desv.

### Fungi.

**American Gymnosporangia or "Cedar-apples."**‡—As a contribution to the natural history of the Uredineæ, W. G. Farlow describes in detail eight species of *Gymnosporangium* or "Podisoma," found in the United States, giving the following as the diagnosis of the genus:—"Spores yellow or orange-coloured, usually 2-celled, occasionally 1–6-celled, on long hyaline pedicels, imbedded in a mass of jelly, which when moistened swells into columnar or irregularly expanded masses. Mycelium parasitic in the leaves and branches of different Cupressineæ, producing in them various distortions." This he supplements with various descriptions of eight species of the æcidial form *Rœstelia*, which he thus defines:—"Æcidia usually hypophyllous, lower part sunk in the swollen tissues of the leaves, forming above cylindrical, conical, or oblong projections which are

† J. Müller, 'Les Characées genevoises.' Extr. du Bull. Soc. Bot. Genève, 1881. See Hedwigia, xx. (1881) pp. 94 and 104.

‡ Anniv. Mem. Boston Soc. Nat. Hist. 1880, 38 pp. (2 pls.).

often split and fringed in the upper part; peridium composed of large colourless cells; spores brownish or orange-coloured, subglobose when mature, formed in moniliform rows. Spermogonia punctiform, forming minute dark-coloured pustules in discoloured spots on the upper surface of the leaves. Mycelium infesting the leaves and stems of different Pomeæ."

As regards the genetic relationship of particular species of *Gymnosporangium* with particular species of the æcidial form, the geographical distribution of the different species of the two forms presents great difficulty in the way of the specific identification proposed by Oersted and Ráthay.* Artificial cultures of spores of the various species of *Gymnosporangium* on leaves of Pomeæ were as a rule without result; and when results were obtained, they were difficult to reconcile with the views of these writers. When spermogonia did appear it was, at least in some cases, probably due to the presence of the mycelium of a *Rœstelia* in the leaves. Professor Farlow considers, therefore, that the assumed genetic connection of these two genera is a question which requires further investigation before it can be considered as satisfactorily established.

**Cancer of Apple Trees.**†—R. Goethe claims to have determined the cause of the cancer (*Krebs*) of apple trees to be the growth of the fungus *Nectria ditissima* in the cortical parenchyma, as R. Hartig had previously shown to be the case in the cancer of the copper beech. He succeeded in propagating the parasite in the diseased places both from conidia and from ascopores. The same fungus also produces cancer on various kinds of pear trees; each can be propagated on the anther, and the conidia or ascospores of the *Nectria* from the apple produced cancer in the beech and sycamore, and conversely. The cancer in all these trees is therefore due to the same cause; and the best mode of preventing its attack is to protect the trees as far as possible from injury to the bark, and when this does occur, and the disease begins to manifest itself, to cut out the whole of the diseased tissue, and anoint carefully with warm coal-tar.

**Peziza Fuckeliana and Sclerotiorum.**‡—R. Pirotta has afresh investigated the genetic connection of *Botrytis cinerea*, *Peziza Fuckeliana*, and *Sclerotium echinatum*, and considers it conclusively established that they are metagenetic forms of the same species, viz. the conidial, ascophorous, and mycelial generations. The experiments were performed with the necessary precautions to prevent the intrusion of error, and the following were the main results:—

1. Sclerotia of *P. Fuckeliana* from fallen vine-leaves developed mostly into luxuriant conidiiferous tufts of *B. cinerea*, one only giving rise to the cupules of *Peziza*. These conidia sown on young vine-leaves produced abundant *Botrytis*, and sclerotia perfectly resembling those of *S. echinatum*.

* See this Journal, iii. (1880) p. 995.

† Monatsschr. Deutscher Garten, 1880, p. 79. See Bot. Ztg., xxxix. (1881) p. 228.

‡ Nuov. Giorn. Bot. Ital., xiii. (1881) pp. 130–5.

2. The conidia of *B. cinerea* found abundantly on a *Vaucheria* sown in a damp chamber on boiled grapes, produced abundant *Botrytis* and a *Peziza* resembling *P. Fuckeliana*. The ascospores sown in the must of boiled grapes in a damp chamber, produced an abundant mycelium, and sclerotia, but without any trace of *Botrytis;* the same ascospores sown on vine-leaves gave birth to sclerotia and *Botrytis;* these sclerotia sown in sand produced *Botrytis* and cupules of *Peziza.*

3. The *Botrytis cinerea* growing naturally on decaying fruits, gave rise successively to the sclerotial, conidial, and ascophorous generations.

4. The ascospores of *P. Fuckeliana*, and the conidia of *B. cinerea*, both cultivated in the open, developed in an identical manner, giving rise to a uniform resting mycelium, which may remain for a long time after the death of the ordinary mycelium, after which it developes into a new mycelium, and finally into sclerotia.

5. The same sclerotium may develope either into *Botrytis* or into *Peziza*, the conidiiferous filaments being the direct continuation of special mycelial filaments of the sclerotium.

6. The cycle of development of *P. Fuckeliana*, starting from the ascospore, may be stated as follows:—

Ascospore.

| | | |
|---|---|---|
| Sclerotium | Sclerotium | Botrytis |
| Botrytis | Ascospore | Sclerotium |
| Botrytis | | Botrytis |
| Sclerotium | | Botrytis |
| Ascospore | | Sclerotium |
| | | Ascospore |

7. The generic name *Botrytis* has the advantage of priority, and the various stages of development may be stated as follows:—

Botrytis (Mich. et auct.) genus Discomycetum.

*a.* Mycelium sclerotiogenum (Sclerotia auct.).
*b.* Forma conidiophora (*Botrytis* sp. auct.).
*c.* Forma ascophora (*Peziza* auct.; *Sclerotina* Fuckel pr. p.; *Rutstroemia* Karst. pr. p.).

Botrytis cinerea (Pers.).

Mycelium sclerotiogenum (*Sclerotium echinatum* Fuckel)—f. conidiophora (*Botrytis cinerea* Pers., *B. acinorum* Fres., *B. vulgaris* auct. et forsan *B. elegans* Lk.)—f. ascophora (*Peziza Fuckeliana* De B., *Sclerotinia Fuckeliana* Fuckel).

To this genus would belong all the forms of *Peziza* with a sclerotial mycelium and a conidiiferous *Botrytis*-form.

The second species of *Peziza* studied was derived from sclerotia

growing on the kidney bean, and having the characters of that described as *Sclerotium compactum*. Sown in sand they produced numerous *Peziza*-cupules easily identified as *P. sclerotiorum* Lib. The ascospores of this *Peziza* cultivated in various nutrient fluids produced an abundant mycelium, which gave rise to resting mycelia similar in all respects to those resulting from the mycelium springing from the ascospores of *P. Fuckeliana*. Very numerous experiments in culture failed to produce any conidiiferous form, but always sclerotia, which again gave birth to *Peziza*-cupules. The cycle of development, as at present known, is therefore confined to—

Ascospore
|
Sclerotium
|
Ascospore

To this form it seems proper to confine Fuckel's name *Sclerotinia*, and to it therefore will belong the synonyms *Sclerotinia Libertiana* Fuckel (*Peziza sclerotiorum* Lib.), *S. Kauffmanniana* Tichom., and perhaps *P. Carreyana*, *Duriæiana*, and *Candolleana*.

**Puccinia Lojkajana.***—This very rare fungus has at present been found only in a locality in Hungary, from which it takes its name, and in the Botanic Garden at Parma, where it is parasitic on *Ornithogalum umbellatum*. G. Passerini has studied it in the latter situation, where it forms elongated yellow spots on the leaves of the host, the rupture of the epidermis exposing the brown spores; the parasite thus presenting the general appearance of belonging to the Ustilagineæ rather than to the Uredineæ. The leaves become deformed and ultimately perish, and the infected plants are not known to flower. Neither the stylospore nor the æcidio-form of the fungus has yet been detected, so that its mode of propagation is involved in doubt. The mycelium of this *Puccinia* would appear to differ from that of all other species known in attacking the perennial parts, viz. the bulbs rather than the annual parts of the plant, and thus being enabled to persist through the winter, having the character of a hibernating mycelium in common with *Gymnosporangium fuscum* according to Cramer, and with *Peridermium elatinum* according to De Bary. The development of the other metagenetic or æcidial form is therefore not indispensable to the propagation of the species.

**Septoria Castaneæ, the Chestnut-disease.**†—The disease of the chestnut-tree which recently made its appearance in Italy,‡ spread last year with extraordinary rapidity, and is further described by A. Piccone. In Liguria, and especially in the province of Genoa, he found the trees everywhere attacked by it, almost entirely losing their leaves early in the summer, and in consequence failing to develope their fruit. He has no hesitation in attributing the malady to the attacks of a parasitic fungus, *Septoria Castaneæ* Lév., on the leaves and also on the branches. Its extraordinary development, which was most

* Nuov. Giorn. Bot. Ital., xiii. (1881) pp. 127–30. † Ibid., pp. 124–6.
‡ See this Journal, *ante*, p. 282.

striking in wet or cold localities, he attributed to the excessive humidity of the preceding summer. No organs of reproduction were observed.

Bacteria living at High Temperatures.*—Cohn has assigned 55° C. as the highest limit of temperature at which the Bacteria he studied, and notably Bacilli, still lived and developed. This temperature is, in fact, M. P. van Tieghem says, fatal to most of these organisms. Nevertheless he last summer observed several which developed rapidly and formed their spores regularly, at the considerably higher temperatures of 60°, 65°, 70°, and up to 74°. In a d'Arsonval apparatus, regulated at the latter temperature, several successive growths of two of the organisms were obtained.

One was a *Micrococcus* whose spherical cells were arranged in long chaplets, the "beads" measuring 0·0015 mm. They developed throughout the nutritive fluid, which they rendered uniformly turbid. The other was a *Bacillus* with very pale joints, always stationary, spreading over the surface in a thin mucous pellicle. Its cells disunited immediately after their division and placed themselves parallel to each other, thus forming long palisade-like series in which the "battens" were bound together by a gelatinous substance. They formed their spores rapidly and disappeared, leaving those spores arranged side by side in transverse series as they themselves had been.

In these cultures an infusion of kidney-beans or broad-beans filtered and perfectly neutralized was the nutritive fluid employed. It was first heated in the stove to 74°, and the sowing made on the spot. Thus the objection cannot be raised that the development observed could, at least in part, have taken place during the time consumed in heating the liquid. It is also necessary that the latter should be and remain neutral. Should it be slightly acid all development will soon cease. This explains the fact that, under these conditions, the development of the two organisms only took place during the first two or three days after the sowing; later on the fluid again became clear, and thenceforth sterile. A certain amount of acidity produced by the organism itself is then always observable, which soon renders the fluid uninhabitable by it. Moreover, the *Bacillus* quickly produced its spores, which were set at liberty after the end of the second day.

At the temperature of 77° the development of the *Bacillus* no longer took place, and fluids sown with its spores preserved their clearness.

In conclusion, M. P. van Tieghem mentions that he is induced to publish these observations by the remarks of M. P. Miquel † of the existence in ordinary water, especially that of the Seine, of an immobile and filamentous *Bacillus* that "readily supported a temperature of 60° to 70°," and, cultivated in a neutralized meat infusion at 69° to 70°, "produced filaments, pellicles, and spores, the luxuriance

* Bull. Soc. Bot. de France, xxviii. (1881) pp. 35–6.

† 'Annuaire de l'Observatoire de Montsouris pour 1881 (Météorologie),' p. 464.

of whose vegetation and fecundity left nothing to be desired." At 71° to 72° this *Bacillus* died. "It is curious," observed M. Miquel, "to see an organism living and swarming in a liquid in which the hand is scalded in a few seconds."

The two species observed by the author passed this limit, and it is possible others may yet be found capable of developing at still higher temperatures.

**Bacteria in Diphtheria.***—R. R. Gregg contends that the three forms of so-called bacteria in diphtheria are nothing more than the three ordinary and regular stages of the fibrillation of fibrin of which the diphtheritic membranes are composed, the micrococci being *granules* of fibrin (1st stage of fibrillation), the rod-like bacteria *fibrils* of fibrin (2nd stage), and the spiral bacteria *spirals* of fibrin (contractive stage of its fibrils). Three figures are given in illustration of these stages. "Thus it will be seen that this whole question of the membranes of diphtheria, the falsely assumed bacteria in connection therewith, the coagula of the heart in this disease, &c., may be placed at once upon a purely scientific basis if the profession so desires. And by this showing, too, it will be seen that the exercise of a little common sense and the proper application of a few simple facts to the solution of the subject by the original promulgators and promoters of the bacteria theory, would have saved the medical profession a great disgrace, would have avoided hastening tens of thousands of patients out of the world in the vain effort to destroy by treatment what did not exist, as vegetable parasites, and would have rapidly advanced instead of retarded our knowledge of this terrible disease."

**Fatal Form of Septicæmia in the Rabbit, produced by the Subcutaneous Injection of Human Saliva.†**—Dr. G. M. Sternberg gives an account of some experiments, made in the first instance as a check upon those relating to the so-called *Bacillus malariæ* of Klebs and Tomassi-Crudelli, which shows that his own saliva has remarkable virulent properties when injected into the subcutaneous connective tissues of a rabbit. These results have been fully confirmed by further experiments, which are of special interest now because of the announcement, by Pasteur, of "a new disease," produced in rabbits by the injection of the saliva of an infant which died of hydrophobia.‡

The saliva, injected in doses of 1·25 c.c. to 1·75 c.c., infallibly produced death, usually within forty-eight hours, while blood, putrid urine, liquid fæces, and other matters were innocuous. Saliva of other individuals gave varying results, while surface-mud from the gutters of New Orleans in September invariably proved fatal.

The course of the disease and the post-mortem appearances

* Buffalo 'Investigator.' See 'The Microscope,' &c., i. (1881) pp. 85–6 (3 figs.).

† Sep. repr. from 'National Board of Health Bulletin,' April 30th, 1881, 22 pp. (1 pl.).

‡ Comptes Rendus, xcii. (1881) p. 159. See this Journal, *ante*, p. 286.

indicate that it is a form of septicæmia. Immediately after the injection there is a rise of temperature, which in a few hours may reach 2° to 3° C.; the temperature subsequently falls, and shortly before death is often several degrees below the normal. There is loss of appetite and marked debility after twenty-four hours, and the animal commonly dies during the second night or early in the morning of the second day after the injection. Death results still more quickly when the blood from a rabbit recently dead is injected. Not infrequently convulsions immediately precede death.

The results generally correspond with those reported by Pasteur.

The phenomena detailed result, in the view of the author, from the presence of a living organism in the saliva—a micrococcus—which multiplies abundantly in the subcutaneous connective tissue, and also in the blood shortly before or after death; for—

*a.* The poison is particulate.

*b.* The virulence is destroyed by boiling.

*c.* The saliva loses its virulence when kept for twenty-four hours in a culture chamber, at a temperature of 37° C.

*d.* The addition of one part of a 10 per cent. solution of carbolic acid to two parts of saliva destroys its virulence.

*e.* The effused serum from the subcutaneous connective tissue of a rabbit recently dead produces death attended with the same phenomena as resulted from the injection of the saliva in the first instance.

*f.* This serum loses its virulence by filtration.

*g.* The micrococcus present in the serum from the connective tissue of a rabbit which has succumbed to a subcutaneous injection of saliva, may be cultivated in bouillon made from the flesh of a healthy rabbit, or in the blood serum obtained from a healthy dog, and these fluids thereby acquire a virulence which they did not have before.

*h.* Successive cultures in which but a small drop is taken each time to inoculate a fresh quantity of bouillon, exclude the white and red blood-corpuscles as possible agents in the production of this virulence, and prove conclusively that the veritable cause is the presence of a micrococcus, found first in the saliva, then in the serum from the connective tissue, and (usually) in the blood of the animal killed by the injection of saliva, and finally in each successive culture fluid inoculated (in the first instance) with a small quantity of this serum or blood.

As to the identity of the micrococcus with *M. septicus* of Cohn and that found by Pasteur, the author quotes their descriptions, and says:—

"The foregoing descriptions answer as well for the micrococcus observed by me as if they had been written especially for it, and it is unnecessary for me to say more at present in relation to the morphology of this organism, which apparently is identical with that of the *Micrococcus septicus* of Cohn, and with the organism found by Pasteur in the 'new disease' described by him. Does it then follow that the organisms are identical, and that the phenomena

related by Pasteur, as resulting from the subcutaneous injection of saliva from an infant dead of hydrophobia, and by myself, from saliva of a healthy adult, represent the same disease? By no means. The man of science soon finds that things which look alike are not necessarily of the same kind. Thus of two transparent colourless fluids, one may be harmless water, and the other a corrosive acid; two embryos apparently alike may develope, the one into a man, and the other into a monkey; two seeds of the same size and general appearance may produce the one a cabbage, the other a turnip, &c.

"The argument, then, that because a certain *bacillus*, or *spirillum*, or *micrococcus*, is morphologically identical with another which is proved to be harmless as to its effects upon an animal organism, consequently *it* must be harmless, has no support from analogy any more than it has from experiment. And it is high time that naturalists and physicians should open their eyes to the fallacy of such an argument, as it not only has a tendency to close the minds of those who receive it to the reception of demonstrated truth, but also acts, to some extent, as a bar to the progress of science in this direction."

The morphology of the organism is dealt with in full detail, and is illustrated by a plate reproduced by the heliotype process from photo-micrographs (Zeiss $\frac{1}{18}$ hom. im.).

The author mentions, as having a possible bearing on the subject, that he has been engaged to a considerable extent during the past two years in studies which have brought him in contact with septic material.

**Action of Compounds Inimical to Bacterial Life.***—Mr. W. M. Hamlet finds that hydrogen, carbonic oxide, marsh-gas, nitrogen, sulphuretted hydrogen, potash, soda, and various salts and organic acids, have no effect on bacteria, which readily develope in them all.

On the other hand, chlorine and hydric peroxide were found to kill the bacteria, while potash- and ammonia-alum, ferrous sulphate, chloroform, creosote, carbolic acid, and a few other compounds only partially hinder their growth. "Bacteria may be pickled in creosote and carbolic acid without being deprived of their vitality. Take them out of pickle and surround them with suitable nourishment in the form of albuminous solutions, and their life proceeds uninterruptedly as before."

**Action of Ozone on Germs contained in the Air.**†—E. Chappuis has found that whilst dust collected from the air on plugs of cotton-wool and introduced into solutions of yeast causes a turbidity in a few days, yet if the plugs containing the dust are previously subjected to the action of a current of ozonized air no turbidity is produced at the end of twenty days.

It is evident, therefore, that all germs suspended in the air, capable of developing in solutions of yeast from beer, are killed by ozone.

* Journ. Chem. Soc., xxxix. (1881) pp. 326-31.

† Bull. Soc. Chim., xxxv. p. 390. See Journ. Chem. Soc. (Abstracts), xl. (1881) p. 632.

## Algæ.

**Marine Algæ of New England.***—Professor Farlow contributes to the "U. S. Fish Commission for 1879" an account of all the marine algæ at present known to occur on the coast of the United States to Eastpool, Maine, with the exception of the diatoms. He remarks that, as regards the marine vegetation of the north-eastern coast of the United States, beginning at Eastport, we have a strongly marked arctic flora, which is a direct continuation of that of Greenland and Newfoundland. Proceeding southwards towards Boston, although the luxuriance of growth is less, the general appearance of the flora is unmistakably arctic, with the exception of a few sheltered localities. The northern shore of Cape Cod, from its sandy character, is practically destitute of all species of algæ, except a few forms. Passing to the south of Cape Cod, the flora assumes an entirely different aspect, this being the dividing line between a marked northern and southern flora. The number of species described by Professor Farlow is 230, viz. 32 Cryptophyceæ (6 Chroococcaceæ and 26 Nostochineæ); 88 Zoosporeæ (36 Chlorosporeæ, 2 Bryopsideæ, 1 Botrydieæ, and 49 Phæosporeæ); 11 Oosporeæ (2 Vaucherieæ and 9 Fucaceæ); and 99 Florideæ. These belong to 107 genera. The total number of species increases as one goes southwards, the increase being mainly in the Florideæ.

**North American Algæ.**—Several years ago Dr. Farlow, Dr. Anderson, and Professor Eaton, began the publication of sets of the marine algæ of the eastern and western coasts of North America. The first fasciculus of fifty species appeared in 1877; the second, also containing fifty species, in 1878; the third, containing thirty species, in 1879. The fourth fasciculus has just been issued, and, like the first and second, includes fifty species. The 'American Naturalist'† considers that "it may well be said that it is impossible for any one to get anywhere more satisfactory representatives of the 180 species already included in this important distribution. Not only are the specimens all that can be desired, but the eminent qualifications of the editors for this work give an unusual value and high authenticity to the sets."

**Abnormal Fructification in the Florideæ.‡**—The two forms of fructification of the Florideæ, the sexual cystocarps and the non-sexual tetraspores, are, with very few exceptions, always found on separate fronds. C. F. Ardissone records two instances to the contrary, viz. in *Callithamnion graniferum* (Men. non Kutz.), and *Dudresnaya coccinea*, where they occur on the same frond; and in the latter case the ultimate divisions which bear the tetraspores and the cystocarps respectively, are even part of the same branch. It is worthy of note that these specimens of *Callithamnion graniferum*

* Farlow, W. G., 'Marine Algæ of New England and Adjacent Coast.' (Washington, 1881.)

† Amer. Natural., xv. (1881) p. 652.

‡ Rend. R. Ist. Lombardo, xiv. (1881) Mar. 10.

presented also another departure from the normal structure, the cystocarps being in the form of normal favellæ, instead of, as is usually the case, in that of lateral seirospores. The species was, however, well distinguished by the ampulliform terminal articulations of the branches.

**Congenital union of growth on the Thallus of the Pollexfenieæ.*** —The apical growth of the Rhodomeleæ has been shown to depend on the segmentation of a single apical cell. Falkenberg has, nevertheless, observed in the Pollexfenieæ—a group consisting of the genera *Pollexfenia*, *Jeannerettia*, and *Placophora*—that the thallus grows, along its entire unilamellar anterior margin, by means of an apical angle; the different marginal cells showing also different modes of division. A close examination shows that we have not here an apical angle composed of cells originally of equal value, as in *Taonia*, *Padina*, or *Peyssonnelia;* but that the growing margin of the flat thallus is composed of the apical cells of unequal branches of a much-branched *Polysiphonia*-like system, all the branches of which that lie in the same plane having congenitally united in their growth through their whole length.

**Structure of Terpsinoë.†**—O. Müller has already shown that in the diatom-genus *Epithemia* there is a system of septa which divides the space enclosed in the shell into compartments. In addition there is another septum, called by him the *intermediate plate*, which divides the cell-cavity in two along its longest diameter. The same he now states to be the case with *Terpsinoë musica* and *americana.* In these species the intermediate plate remains in a very rudimentary, scarcely perceptible condition. The margin of the shell projects in a cushion-like manner into the cavity to meet the septa. A full description is given of the number and relative position and size of the septa.

With regard to the question whether this genus conforms to the Macdonald-Pfitzer hypothesis that the shell is double, the author points out that the optical image of the boundaries of the hoop is very defective, and that a refutation of this hypothesis can best be obtained by simply observing the microscopic image of the margin of the hoop.

The superposition of the hoop may exist without being discernible in the optical section of the lateral margin. The section of two membranes of the same substance, and therefore the same refractive power, which lie so closely on one another that another refractive medium cannot be interposed, necessarily gives the impression of a single membrane of double thickness. But when a differently refracting medium appears at the free edge of the superposed membrane, and extends a little way, the appearance is produced as though a lamella had been split off from the otherwise homogeneous membrane. This is precisely the appearance of the margins of *Terpsinoë;* such apparently split-off lamellæ frequently

* Göttinger Nachr., Dec. 15, 1880. See Bot. Ztg., xxxix. (1881) p. 159.
† SB. Ges. naturf. Freunde Berlin, 18th Jan., 1881, 14 pp.

make their appearance in different places, and disturb the uniformity without justifying the conclusion that the separation is complete.

On examining fragments of the shell and hoop, it is found that both have round pits; but whilst the pits on the shell are comparatively large, those on the hoop are decidedly small, and this enables us to distinguish to which a given portion belongs. Round the shell, however, runs an annular zone, which is quite free from pits, viz. the zone of the cushion-like rim. On the halves of the hoop there is, in addition to the groove, a zone without pits, which is very narrow and lies near the free edge, but there are besides semicircular free places, situate close to the shell-margin of the hoop; the whole remaining surface is thickly dotted.

By means of well-corrected immersion lenses, especially with the new homogeneous-immersion lenses, and by carefully using the micrometer screw, it is possible to bring into focus the outermost surface of the cell in such a way that the different images of the dots on the hoop and the shell are recognized as immediately over one another; that is, they appear one after the other. This optical reaction is effected with perfect certainty, and, with proper optical instruments and manipulation, can be demonstrated to any one.

The young shell—and this deserves particular attention—begins to develope the halves of the hoop only when the cell is ready to divide. When this is effected, the two cells formed remain united in *T. musica* for some time, and apparently only separate before the fresh division; hence in this species only unicellular or double individuals were met with, never any with three or four cells connected. In those consisting of two cells, therefore, the two young (interior) shells were always found without hoops.

Viewed from the broad side of the hoop, when the focal adjustment is highest, the image of the fine pits of the hoop is obtained on a double cell in two places; on lowering the tube the coarser pits or the broad undotted zone come into view. At two other places, on the other hand, of the same double cell, there is nothing of the kind visible; over the undotted shell there appear no hoop-pits. If we define these places with reference to their position and regularity, the result arrived at is that this image of the superposition can only be obtained from young shells, which, according to the Macdonald-Pfitzer theory, must be the enclosed ones. Denoting the enclosed shells by *e*, the free by *f*, the sequence in double cells is *f e e f*.

This, however, would only prove that the young shells are covered by a hoop-membrane; which would also be the case if a simple piece of hoop connected both mother-cells. But in *T. americana* triple cells are often met with, and from them a proof may be obtained. The development of these triple cells is undoubtedly this:—one of the double cells remains barren, whilst the second proceeds to a fresh division, and at the same time remains connected with the first; the frequent occurrence of double cells in which one shows a broadened hoop-space would alone prove this; but the sequence of the free and enclosed shells, which in all the cases examined uniformly corresponded with the formula *f e f e e f*, puts it beyond doubt. If the

triple cell were the product of an amputated quadruple cell which had originated from double division of a double cell, there must necessarily be found either at the beginning or the end an *enclosed* shell, since the quadruple formed regularly from the double cell can only have the formula *f e e f f e e f*.

The formula *f e f e e f*, which can be positively demonstrated in all triple cells, can only be explained on the assumption of the hypothesis of there being two shells; it is quite incomprehensible on the assumption of a simple hoop, unless the most complicated process is arbitrarily supposed.

Whilst triple cells frequently occur in *T. americana*, only once was a quadruple found the origin of which was clear. The examination of this gave the formula *f e e f e f e f*. This formula shows first of all that this quadruple could not have originated from the regular division of a double, but must necessarily have been derived from a triple cell; further, it completes the proof of the Macdonald-Pfitzer hypothesis, since every other explanation of its origin appears inadmissible.

**Remarkable Vital Phenomenon in the Adriatic.***—In the year 1872, and again in 1880, a remarkable development took place on the surface of the Adriatic, in the neighbourhood of Trieste, of a mucilaginous floating substance, in such vast quantities as to seriously interfere with the fishing. This has been examined by Count (Abbé) Castracane, who attributes it to the extraordinary multiplication of various diatoms, in opposition to the view of Zanardini, by whom it is attributed to a new alga called by him *Dermoglœa limi*. The diatom which plays the greatest part in the formation of the slime appears to be *Nitzschia macilenta*, accompanied, however, by numerous other forms; and the mucilage, shown by chemical tests to consist of cellulose, is its ordinary gelatinous envelope. The researches of the 'Challenger' have shown that diatoms are not uniformly distributed through the deep sea, but are found especially near the shore, and in colder and brackish water. The time of the year when the phenomenon in question was observed, June and July, favours the hypothesis that it was partly due to the rapid melting of the snow on the Alps and the Apennines, which brings down an immense quantity of fresh and cold water into the Adriatic: and that the extraordinarily rapid multiplication of the diatoms was promoted by the great stillness of the water. The phenomenon was accompanied by a remarkably brilliant phosphorescence caused by myriads of *Peridinium* (*Ceratium*) belonging to several species.

**Uses of Diatoms.**†—As a supplement to Dr. M. Lanzi's paper, referred to at p. 512, may be mentioned an article by Mr. H. G. Hanks, State Mineralogist of California, in which he enumerates the following additional uses of diatomaceous earth:—

"It is a very convenient source of soluble silica, employed in the

* F. Castracane, 'Straordinario Fenomeno della vita del mare, osservato nell' Adriatico nella estate del 1880.' Roma, 1881, 13 pp. Estrat. d. Atti Accad. Pontif. Nuovi Lincei, xxxiv.

† 'Mining and Scientific Press,' July 9th, 1881.

manufacture of silicate of soda or potash, also known as soluble glass. The manufacture of this compound is simplicity itself. Carbonate of soda or potash, as the case may be, is dissolved in boiling water to saturation, in a capacious iron kettle, and fresh hydrate of lime added until all the carbonic acid is precipitated, and the alkali becomes caustic. Diatomaceous earth in a powdered state is then added as long as silica is dissolved, and the whole covered and allowed to cool. When the insoluble matters have settled, the clear liquid is drawn off and evaporated in a clean vessel to the required density.

Diatomaceous earth is also used in the manufacture of porcelain, and it is a constituent of certain cements and artificial stones. At one time it was claimed to be a fertilizer, but this is thought to be a fallacy, although Ehrenberg states that the fertilizing power of the Nile mud is furnished by fossil Infusoria.

Slabs of diatomaceous earth absorb liquids with avidity, and are used in laboratories for drying crystals and filters. This property might be more generally utilized if better known.

A convenient contrivance for lighting fires is a lump of diatomaceous earth with a handle of stout iron wire. It is dipped into a vessel of petroleum, placed in the stove or fireplace, and lighted with a match. It continues to burn safely for some time. It can be used again and again. No person, however, should make use of it who has not the common sense to carefully set away the vessel containing the coal-oil before lighting the match.

Bricks that float in water are made of diatomaceous earth mixed with one-twentieth part of clay and well burned. The art of making these floating bricks was well known in the time of Pliny, but was afterwards lost. It has recently been rediscovered. In the Italian department of the Paris Exposition of 1878 these bricks were exhibited, and attracted considerable attention. Floating bricks, made wholly of Californian material may be seen in the State Museum.

Kieselguhr or "flint froth" of the Germans, from a deposit in Hanover, is extensively used in the manufacture of dynamite, giant powder, lithofracteur, and other explosives. Diatomaceous earth absorbs from three to four times its weight of nitro-glycerine, with the advantage over other absorbents of retaining the nitro-glycerine under greater pressure. Dynamite contains 27 per cent. and lithofracteur 23 per cent. of diatomaceous earth. Before the kieselguhr can be used, it is subjected to treatment to remove water, all organic matter and coarse particles. It is first calcined in a succession of furnaces, crushed between rollers, and sifted.

Diatomaceous earth is largely used in the manufacture of soap, to mechanically increase its detersive power. The Standard Company receive large quantities of it from the southern counties of the State.

It is not to be supposed that all the uses of this remarkable substance have been discovered; it remains for the intelligent inventor to search for new applications."

C. W. G. also says * that on examining some of the powder known

* Amer. Mon. Micr. Journ., ii. (1881) p. 158.

as "vegetable sozodont tooth powder," he finds it to be composed chiefly of diatomaceous material, the forms being in both perfect and fragmentary states. Various forms of *Navicula* and *Pinnularia* occur in great abundance, and when mounted in balsam the powder makes an interesting object.

**Striæ of the Diatomaceæ.***—The Count (Abbé) Castracane has published a paper under the title "On the value to be attributed in the Determination of Species to the number of the Striæ of the Diatomaceæ," of which the following is substantially a full translation—the original paper is written in Italian.

"One of the most fortunate epochs for sciences of observation is, without doubt, this half of the nineteenth century, when the attention of theoretical and practical opticians being applied to the construction and perfecting of the Microscope, a new path has been opened for this instrument with a more brilliant future, thanks to Professor Amici and his invention of immersion objectives. Objectives of the highest magnifying powers will now give greatly improved images as regards spherical and chromatic aberration, and beyond all other advantages realized in this way, a much more valuable victory and a much greater progress was the extent of the angle under which the object could be illuminated. It is thus that organisms presenting details of exquisite fineness, and which seemed to defy all power of resolution, have been shown and distinguished from one another by the use of very oblique illumination, so that this angle of aperture of objectives is the principal factor of their value.

The acquisition of an instrument of research so interesting and so efficacious, has led to the discovery of unexpected wonders, and the Microscope has become the inseparable companion of the naturalist, the physician, the botanist, the physiologist, and all those who endeavour to recognize the ultimate forms and the minute structure of organisms and tissues. The Microscope has opened new fields to the insatiable curiosity of mankind thus drawn towards the study of the wonders of the microcosm. Amongst the latter must certainly be reckoned the Diatomaceæ, the knowledge of which, we may say, only dates from the time when the improvements of which we have just spoken were introduced into the construction of the Microscope. This revelation has furnished the most abundant harvest of discoveries to those who have devoted themselves to such researches, and it is not surprising that Ehrenberg, Kützing, Smith, Brebisson, Gregory, Bailey, and many others, have been able to recognize so large a number of diatoms, whilst all those who have occupied themselves seriously with this study know that the discovery of new genera and new species is not very difficult, although the selection of these new species is far from being perfect.

But the work of those to whom we are indebted for the knowledge of thousands of forms of the Diatomaceæ must necessarily suffer the consequence of the rapidity with which the number of the new

* Atti Accad. Pontif. Nuovi Lincei, xxxi., Sess. VI., 26th May, 1878. See Journ. de Microgr., iii. (1879) p. 283. See also this Journal, i. (1878) p. 152.

organisms has increased. Accordingly it is not astonishing that an identical form or type has often been distinguished by different names, whilst forms different in appearance, and consequently known under different names, are now recognized, after more attentive observation, as belonging to one and the same species, and must consequently be united under the same name. But this constitutes the most ungrateful and arduous task to which we can devote ourselves. It is necessary to know the value of the characters by virtue of which one form may be entitled to be recognized as a specific type, and to eliminate those which may not be equally legitimate. It is thus that we may be able to terminate the confusion which reigns in the nomenclature of the Diatomaceæ, and which forms the greatest obstacle to those who have attempted to undertake their study.

But what are to be the rules to be followed in so delicate a research? in other words, what are the diagnostic characters of the Diatomaceæ by which we may distinguish them from one another specifically? Such is the question which I proposed to myself when I undertook to study seriously this interesting order, and that is the subject which has kept me the longest time in suspense. In fact, every one admits that there is nothing more difficult in nature than the determination of species and the fixing of their exact limits, and some have founded on this difficulty an argument for denying the existence of these limits. Without dwelling on the absurdity of such a doctrine, which would annul at a single stroke the work of our predecessors in the study of nature, and would destroy science itself, I will show how the ordinary difficulties in the determination of specific characters have been increased by the extreme smallness of the organisms, in consequence of which it will never be possible to isolate a living form, to watch its successive evolutions, and to determine thus the independent characters of the organic evolution. Such characters, recognized as constant and invariable, would constitute bases for establishing the scientific characteristics and determining the distinct and autonomous types.

In such a state of matters, and awaiting the time when the means of making a diatom grow in a narrow cell shall have been discovered (as the mycologist makes the lower fungi grow in a moist chamber), let us see what are the characters which these wonderful organisms present—such of the characters as provisionally at least may serve for the determination of the species. It will be wise to occupy ourselves with only one point at a time (when several present themselves which are equally difficult), and we will content ourselves with dealing with striation, which distinguishes nearly all diatoms, and which forms the most beautiful and most curious part of their ornamentation. This striation is precisely that which most strikes the attention of the observer, and on that account, as soon as ever the Diatomaceæ were studied and described, the striation was the first point that was noted, and then an endeavour was made to determine its fineness by calculating how many striæ are contained in a given space, as in the $\frac{1}{100}$ of a millimetre.

So long as the diatoms were not too small, and above all, that the

striation did not require the highest powers of the Microscope and the most delicate disposition of the illumination, there was not much difficulty in determining the number of the striæ contained in a given space; but when the progressive improvement of the Microscope enabled the granulations of the *Grammatophora*, *Pleurosigma*, *Nitzschia*, and *Amphipleura* to be distinguished, the attempts which different observers made to measure the fineness of the sculpturing led to very discordant results. The authority of these observers prevented the differences in the measurements from being attributed to errors, and this was the origin of the opinion that the number of the striæ comprised in a given space is not constant, and could not constitute a proper character for the determination of species. But the divergence in the results obtained often arose from the fact that types had been taken for measurement which were not really identical, and did not belong to the same species or variety. Moreover, one method of measurement had deplorable consequences. It is thus, for example, that Messrs. Sollitt and Harrison, of Hull, in affirming that they had found that the number of the transverse striæ of *Amphipleura pellucida* is not less than 120,000 per English inch (5200 in a millimetre), have certainly fallen into error, for notwithstanding the important progress which has been made in late years in the magnifying power of the Microscope, we have not arrived at anything beyond the definition of the striæ, and moreover, such a number of striæ notably surpasses the limit of visibility, as Professor Helmholtz has recently established. The method of measuring by an eye-piece micrometer would be the best (as certainly it is the most rapid), if at the same time it was free from error. But when we deal with details of an excessive fineness, and such as almost defy the resolving power of the most perfect and powerful objectives, it is extremely difficult, and leaves room for a great deal of error, to determine with precision the exact number of striæ comprised in a division of the eye-piece micrometer, the number of which is the smaller as the magnifying power is the greater. When we multiply this number of striæ comprised in a division of the micrometer by the value of that division, the probable error will become so much the greater, and such that the result may be far removed from the truth. It is thus that the two microscopists above named have been led into error by the employment of a bad system of measurement as regards the striæ of the *Amphipleura*, the number of which they have given much beyond the truth.

Thus the difficulty in the determination of the number of striæ in a given space, on the valves of the Diatomaceæ, the disparity in the measurements made by different observers, and, at the same time, the fancy of those who will not admit the existence of species (these, although devoid of every positive argument, and not basing their objections upon experience, affect to consider every organic form as accidental, and as a transitory state of an organism in actual and incessant evolution), all these circumstances have contributed to their denial of the value as regards specific character in the number of the striæ on the valve of a diatom.

By way of proof of this assertion we may cite the interesting discussion which took place * on the supposed identity of *Navicula rhomboides* Ehr., *Navicula crassinervis* Breb., and *Frustulia saxonica* Rab., a discussion in which Dr. Dallinger, Dr. Wallich, and Messrs. Slack and Ingpen took part. This controversy arose, less from the point of view of the study of the Diatomaceæ than in regard to the adoption of their valves as tests for the quality of objectives. In this discussion the illustrious microscopists, Kitton, in England, and Professor H. L. Smith and Colonel Dr. Woodward, in America, added the weight of their authority before the Royal Microscopical Society of London, at the meeting of the 6th December, 1876, on the occasion of a paper by Mr. Dallinger. The very great analogy which exists between these three types is evident and undeniable, but from this analogy can it be concluded that there is identity? Though I may be taxed with temerity, I will take the liberty of replying to this pleiad of illustrious naturalists that this deduction does not seem to me to be just, and that if we are to rely on such arguments in the study of nature we shall soon upset all classification and destroy all notion of species. Being obliged by the extreme smallness of the organisms to content ourselves with reasoning on that which materially and actually appears to our eyes, supplying by inferences from probability, the want of reliable arguments furnished by experience, it seems to me that we must consider the following reasoning sound: When in a sufficiently abundant and pure collection of diatoms several forms resembling each other shall be found, which by numerous specimens of different sizes represent a continuous gradation between the two extremes of the series, then only shall we be able reasonably to conclude that these different forms belong to a single species. Whence it results that a deposit of fossil diatoms can never furnish a basis for probable deductions on this matter, since in this case we have to do with a singular mixture of species of different genera and not with an assemblage which can be considered as the components of a single stock or family, or of the same generation.

Returning to the assumed identity of the three types above described, no mention has been made in the discussion to which it has given rise of any gathering in which these three types have been found united, unless it is in the deposit of Cherryfield, in America, in which only *Navicula rhomboides* and *N. crassinervis* exist. Also, not being aware up to the present time of any gathering of living diatoms in which the three forms are found united, it seems to me a sufficient argument against admitting for the present their supposed identity. This argument, however, is only negative, and as there is no proof the identity remains possible. But there is a positive argument which, if I am not mistaken, refutes that which considers the three forms other than three distinct and autonomous types. If we examine attentively the three diatoms, it will be found that the transverse striation of *Frustulia saxonica* of the Typen-platten of Möller has

* Mon. Micr. Journ., xvii. (1877) pp. 1, 73, and 173.

3400 striæ to a millimetre, whilst the longitudinal striæ are 3600. By the same measure, *Navicula crassinervis* has 1400 transverse striæ, whilst the longitudinal are not less than 2400. Who can say now that the three types are only one species? Up to the present time there is no positive reason or experience which can authorize our admitting that a diatom presents such an irregularity in its striation that a frustule has the transverse striæ notably finer than the longitudinal, whilst another frustule of the same species has an entirely opposite arrangement. It is true that there exist species whose striæ are distributed in a singularly irregular manner on the surface of the valve, *Eunotia formica* Ehr. for example, but the distribution of the lines in the three types above referred to shows, on the contrary, an admirable regularity over the whole surface of the valves.

But having condemned as leading to error the use of the eye-piece micrometer for counting the striæ, a process to which I have attributed for the most part the divergences in the determination by different observers of the number of the striæ, having then spoken of the number as counted by myself in the transverse and longitudinal directions on three different *Naviculæ*, one of which is the most difficult to resolve of any I know, it may be asked what process I have followed—which is one so exact that I am able to disagree with microscopists of incontestable authority? This question is very proper, and I hasten to reply to it so that every one may judge if I am wrong in relying on the correctness of my figures, and so that the exactness of my process being once recognized all may profit by it. I use the ordinary process of photo-micrography, and I have made collections of about 3000 photographs of diatoms under the uniform amplification of 535 diameters. I employ negatives on glass, and with a suitable apparatus I project the photograph of the diatom on the opposite wall of my laboratory enormously enlarged. I then put over it a piece of paper cut so as to represent exactly $\frac{1}{100}$ mm. under the same conditions, that is to say, taken from the photo-micrographic image of a millimetre divided into 100 parts and enlarged to 535 diameters. Superposing the paper on the clearest and most regular part of the image, I count or mark each stria or granule, and the number obtained multiplied by 100 gives me the number comprised in a millimetre either longitudinally, transversely or obliquely, according to circumstances. I do not think it can be denied that this method is a very accurate one; the possible error is hardly worth notice. It is true that the process implies the employment of photography, which, although it can be of great assistance to the naturalist and microscopist, is not yet within reach of every one, nor in habitual use with any. With less convenience, however, one may arrive at the same result by using the camera lucida, or better still, by projecting the diatom directly by means of a good solar microscope.

I have employed this process of measurement to enable me to form a correct opinion on the number of striæ, its constancy or variability in a given species, and to enable me to determine whether it was able to furnish a reliable character in the determination of

species. In his 'Synopsis of the British Diatomaceæ,' vol. ii. p. xxiv. of the introduction, Smith expresses himself thus: "Whether the striæ . . . . are mutually parallel or radiate in their arrangement; reach the median line or are absent from a greater or less portion of the valvular surface;—whether the cellules themselves are arranged in squares or disposed in quincunx; and the striæ in their transverse direction are consequently parallel or oblique in reference to the margin or the median line—the relative distances of the striæ and their greater or less distinctness—all these are features which may safely be regarded as of specific importance . . . , though subject to slight modifications arising from the accidents of locality and age, &c." However great this authority may be, I have preferred to rely upon experience, which is in fact the sole supreme judge and without appeal in such a matter. I think that two forms found in different localities and at different times, however great the affinity which they may present *inter se* in their characters, may form two types closely bordering upon one another, but nevertheless independent and distinct, and destined to produce their own form through an indefinite number of generations. We see this fact happen in many other orders of organisms. Whether these are better called *varieties* than *species*, seems to me wholly indifferent, the distinction between the two words depending on the different value which is commonly given to them, a value and signification considerably elastic—provided always that we recognize the permanence of the form in the successive generations; and this exact permanence of form in the smallest peculiarity of structure in the Diatomaceæ is demonstrated as a constant law by my study of those of the carboniferous epoch.

However, when I happened in a certain locality to find a collection, composed of myriads of frustules evidently belonging to a single species, and forming a single family,* I determined at once to make a most attentive examination, feeling assured that in such circumstances only could the most conclusive elements be obtained for recognizing the extent of the possible modification of the typical form. These circumstances are not at all frequent, although they are sometimes found; I therefore recall with regret that in the early times of my studies on the Diatomaceæ, being desirous of obtaining new types, I was vexed at finding gatherings composed of one or two forms only, all which I rejected, not knowing then the profit which I might draw from them. In gatherings of this kind formed of masses of frustules belonging to a single species, we find a series of forms varying in size and presenting sometimes notable variations in outline. But in reviewing the different dimensions and outlines of the frustules, we recognize after attentive examination that amongst these frustules there is a complete gradation, so that in passing from one to the other by insensible degrees we prove the identity of the extreme terms of the series. Moreover, when we see at the same time that the disposition of the striæ on the valves (rows of granules or any pecu-

* Produced by a single sporangial frustule.—Ed.

liarity like nodules) remains perfectly constant and uniform, we recognize that all the frustules of the collection, notwithstanding the differences in size and outline, belong to the same species.

One of the most favourable circumstances for my views was afforded more than twelve years since, when I was permitted, thanks to the courtesy of M. Alphonse de Candolle) to select from the very rich herbarium of the illustrious botanist of Geneva, some small fragments of Utriculariæ coming from very different localities, and which I found incrusted with diatoms. One of these Utriculariæ came from Rio de Janeiro, another from Java, and a third from Senegal. All three were equally covered with frustules of *Eunotia formica* Ehr. In reference to this fact, I may call attention to the singular peculiarity that the same very rare species of diatom is always found on the same plant, although the latter comes from three very different parts of the globe, a circumstance which may, in my opinion, lead to the conclusion that the Diatomaceæ are not only epiphytes, but parasites. These three different gatherings all showed the characteristic form of *Eunotia formica*, with the angular swelling in the centre, the intermediate constrictions, and all the other characters of nodules and pseudo-nodules and moniliform transverse lines, interrupted by an excentric hyaline line, and unequally distributed. Moreover, the three gatherings contained numerous frustules of very different size and outline, but all presenting the same peculiarities of structure; thus not leaving the least doubt that they all belonged to the same species, *Eunotia formica*. The longitudinal axis in the largest forms was five times the size of the same axis in the smallest forms, and in the latter no indication of the central swelling could be seen, their aspect being rather linear, or showing a slight constriction. I have before me a series of photographs which I have made, representing the entire series of these different forms: looking at the distance of the striæ (especially in the largest and most characteristic specimens), these being very close at the extremities, wider in the centre, and still wider in the two intermediate constrictions; following the gradual variations of outline and size of the frustules, it is impossible not to see that these represent nothing else than different stages of development, and that in this diatom there is at least a bilateral *auxesis*, and perhaps also a simultaneous dilatation or stretching of the middle parts between the centre and the extremities. The different forms of this diatom have also been seen by A. Grunow, and figured in the paper which he published on the fresh-water Diatomaceæ of the Island of Banka.

When we consider the uninterrupted series of *sizes* and *outlines*, all the structural characters remaining at the same time absolutely identical, we are necessarily led to regard all these frustules, although of different dimensions and outline, as belonging to the same species, and representing simply different degrees of organic development. But in this comparison, the character the constancy of which is the most difficult to establish, is the fineness of the striæ which ornament the valves, that is, the number contained in a fraction of a millimetre, so that the invariability of this character in frustules of different

sizes belonging to the same species may be verified. It seems to me so much the more necessary to demonstrate this fact in an irrefragable manner, because it is precisely on this point that there is the greatest disagreement in the opinions of those who are regarded as having most authority in the matter, and, moreover, the deductions which may be drawn from it would be of the highest importance to elucidate the biological laws to which the whole family of the Diatomaceæ are subservient. Amongst the observers who are the most able and of the most authority, must be first mentioned Dr. Wallich, whom I have the honour to know personally, but whom, entirely from the love of truth, I am obliged to contradict. At the meeting of the Royal Microscopical Society of London, of the 3rd January, 1877, he read a paper "On the Relations between the Development, Reproduction, and Markings of the Diatomaceæ," * in which he said that "whilst the *total* number of the striæ on the valves of a diatom may remain nearly uniform in every valve of the same species, the number of striæ on the fractional part of a valve (as a thousandth of an inch) admits of just as much variation as the size of the valve, and proceeds simultaneously with it during division, but not afterwards." This opinion could not be enunciated more explicitly, but is it in accordance with experience? Let us see. From the results of the microphotographic method above described, I am able to demonstrate to Dr. Wallich that his view is not sound, that he has without doubt been misled by a preconceived idea, and that he has not verified the fact by personal experience, relying probably too much on the different figures given for the striæ in a particular fraction, by different microscopists who have employed the faulty process of the eye-piece micrometer.†

Every time that by a happy chance I have been able to discover a mass of diatoms all belonging to a single species, mixed with which were frustules of another genus, I have endeavoured to profit by the occasion to make an attentive examination, and to ascertain the nature of the deviations from the typical form which constitute the idiosyncrasy of the species. On these occasions, after having recognized the types and sizes of the frustules which differ the most, but which are connected by a continuous series of frustules of intermediate size and form, so that no doubt can exist as to the identity of the species to which they belong, I reproduce, by means of microphotography, the image of the smallest and of the largest frustules, always adopting the amplification of 535 diameters. Projecting successively the two images on the wall, I count the striæ contained in $\frac{1}{100}$ mm.; *and up to the present time* I have never found a single case in which the number of the striæ is not constant. In two memoirs which I have published in the 'Proceedings' of this Society, one under the title of "Nuovi argomenti a provare che le

* Mon. Micr. Journ., xvii. (1877) p. 61.

† Dr. Schumann, in 'Die Diatomeen der Hohen Tatra,' says that the structure of the frustule and closeness of the striæ depend on the elevation above sea-level. The higher the habitat the smaller the frustule and the closer the striæ. Mon. Micr. Journ., xiii. (1875) p. 265.—Ed.

Diatomee riproduconsi per germi"* ("New Arguments to prove that the Diatomaceæ are reproduced by Germs"), and the other, "Osservazioni e note a elucidazione dello sviluppo delle Diatomee"† ("Observations and Notes to elucidate the Mode of Development of the Diatomaceæ"), I have referred with details to two gatherings which I obtained and examined. The first contained only *Pinnularia stauronciformis* Sm. var. *latialis*, the other only innumerable frustules of *Cyclotella pisciculus* Ehr.; the largest and the smallest valves of the two species compared together gave an identical fineness of the striæ. I have made this year, and with the same result, similar examinations of different species of diatoms from the first Century of the typical preparations of Dr. Eulenstein, particularly *Navicula Jennerii* Sm. (*Scoliopleura tumida*), *Navicula* (*Pinnularia*) *major* Kz., *Isthmia enervis* Ehr., and *Navicula didyma* Kz., on a preparation by Bourgogne. After results so concordant, it does not seem to me possible to doubt that, at least in these species, the fineness of the striæ is the same on valves of different dimensions, that is to say, that the fineness of the striæ is determined by the idiosyncrasy itself of the species, and consequently that, in accordance with Smith's opinion, the striæ and their fineness are *a quality of specific importance.*

Finally, to better convince those who have a contrary opinion, and to prove that the number of the striæ remains constant in large or small diatoms, provided that they belong to the same species, and that consequently we cannot refuse to the number of these striæ the value of a specific character, I will refer to the fact that in the above-mentioned Century there is a very fine preparation of *Isthmia enervis* Ehr., *in situ*, on which the frustules adhere to one another by the angles and are attached to the pedicel. The same pedicel bears large and small frustules united together, so that no more favourable occasion could have been found to test the matter. I then produced with the usual amplification the frustules of extreme dimensions, and measured the lines of small granules on the bands or zones on the one and on the other, and I did not find the least difference in the numbers. I think, therefore, that it is not possible reasonably to maintain the least doubt. If, however, any observer prefers to rely on his own verification, nothing would be more agreeable to me, for I shall then see my assertions confirmed independently.

In speaking above of *Eunotia formica* Ehr., I have referred to the characteristic peculiarity of this very interesting species, that is, that the moniliform striæ are distributed in an irregular manner and are peculiarly grouped and close at the two extremities and wide in the intermediate parts. By this observation I have shown that I do not consider the character of the striæ and their number as a character of an absolute specific value, but that I admitted this value only when the distribution of the striæ on the surface of the valve is regular, a condition which is presented in most cases, as in the *Naviculæ*, the *Synedræ*, and many others. But there is still another consideration

* Atti Accad. Pontif. Nuov. Linc., 19th March, 1876.
† Ibid., 22nd January, 1877.

which I wish to put forward to better explain my views. In the greatest number of different types of Diatomaceæ which I have reproduced and measured by microphotography, I ought to admit that in examining certain species, although well-determined but placed in different preparations, I have found some differences in specimens of the same species, in regard to the number and fineness of the striæ; nevertheless, when I have met with these differences, they have never been considerable relatively and proportionally to their number, for the difference has never exceeded $\frac{1}{5}$. But at the same time I declare most emphatically that up to the present time I have never found the smallest difference when I have compared the frustules which not simply belonged to the same species but also to the same stock.

On these facts depends the validity of all the deductions which can reasonably be drawn from the constancy of the fineness of the striæ on the large and small frustules belonging to the same species and the same stock. I have spoken of these deductions in the paper entitled "Nuovi argomenti, &c." I have there referred to a very pure gathering which I made near the fountain in the "Fields of Annibal," on Mont Cavo near Rocca di Papa, which was solely composed of myriads of frustules of *Pinnularia stauroneiformis* Sm. var. *latialis*, a variety which I thought myself justified in establishing on the ground of the very great difference in the number of the striæ in the form from Mont Cavo, which was 1900 to the millimetre, and in the typical form of Smith, which has not more than 1200 in the same space, a difference which exceeds $\frac{1}{3}$, all the other characters remaining absolutely identical. On this occasion I have deduced from the constancy in the form of the striæ on the largest and the smallest frustules in this collection: (1) That at least in this case multiplication did not take place by temnogenesis or division, for, on the hypothesis of the gradual diminution of the valves and frustules, resulting from the encapsulement of the latter, the striæ ought in the same proportion to become finer and finer, if the very explicit opinion of Dr. Wallich is true, viz. "that the number of striæ in a fractional part of the valve undergoes precisely the same variation as the size of the valve;" (2) That the auxesis, the augmentation of the size of the frustules, must take place by the bilateral addition of new striæ, and consecutive dilatation of the bands or zones which unite the valves; (3) That thus the diatom, although invested with a siliceous coat, is the object of a gradual development and distension because the silex is probably found in a combination with cellulose,* in which it replaces the carbon, a substitution the possibility of which is demonstrated by the labours of the chemists Friedel and Ladenbourg. In support of the second part of this deduction, that is, that in the Diatomaceæ the auxesis must take place by bilateral addition of new striæ and not by perispherical increase as in the Crustacea, I refer to another argument. I have pointed out above that in the collections formed of a single species, there are always found large and small

* Mon. Micr. Journ., viii. p. 194.

frustules, so that the longitudinal axis of some is only the half that of others, or even less. Any one who has examined under the Microscope these interesting organisms, not only on the preparations which can be bought, but better still by gathering them himself, and has had the opportunity of obtaining pure gatherings, will find that the cold Alpine sources will frequently have furnished him with very rich and very pure collections of *Odontidium hyemale* Kz. Under these circumstances, in examining one by one the different sizes of the valve on frustules of the same species, if we take the measure of the longitudinal and the transverse axes, we shall see that the dimensions of the former differ considerably, in that some are only the half and even a smaller fraction of the others, whilst on comparing the transverse axes of the valves of these same frustules there is little or no difference. However, no one could deny that the gradual diminution of the frustules which necessarily results from their encapsulement when multiplication by fission takes place, as has been completely demonstrated by Dr. Pfitzer of Bonn,* ought to produce in the transverse axes the same variation as in the longitudinal.

Urged by the love of truth and by deep conviction, the fruit of long reflection and patient research, I have been induced to explain my mode of regarding the striation of the Diatomaceæ, and the value which should be allowed to it in the classification of species, and to indicate the logical conclusions which I have thought ought to be drawn from it. I know that on this point I differ from the predominant opinion and from the ideas of competent persons whom I otherwise honour, but such is the force of my conviction that I have not hesitated to brave these differences. I retain the hope that these gentlemen, far from regretting my observations, will have the kindness to take them into their serious consideration, and the more so as my opinions on this subject result from the practice which I have invariably employed of drawing the images of the Diatomaceæ by means of microphotography, which, applied to all branches of research, in the natural or experimental sciences, cannot fail to render equally useful services.

I think also it will be agreeable and useful to microscopists, particularly to those who study the Diatomaceæ, to subjoin a Table of the Measurement and the Number of the Striæ which ornament the surface of the valves in certain species. I have extracted this table from my note-book, in which I put down, each time that I take a measure, the number of striæ corresponding to a millimetre.

As nearly the whole of the types which I have reproduced and examined have been taken from Möller's type-plate, I have adopted the names and the order for the genera as they are employed in the catalogue which accompanies that preparation. I do not, however, wish it to be understood that I approve this order, or that I admit certain modifications in the nomenclature, for instance the inclusion in the genus *Navicula*, already so excessively extended, of all the forms which Ehrenberg and Smith have relegated to the allied genus *Pinnularia*."

* Unters. u. Entwickel. Bacill.

| | Longitudinal Striæ per mm. | Transverse Striæ per mm. |
|---|---|---|
| *Epithemia argus* Sm. | 900 | 1200 |
| ,, *constricta* Sm. | ,, | 1450 |
| ,, *zebra* Kz. | 1250 | 1700 |
| ,, *gibba* Kz. | ,, | 1600 |
| ,, *turgida* Kz. | 800 | 900 |
| ,, *ocellata* Kz. var. | ,, | 430 |
| ,, *musculus* Kz. | ,, | 1750 |
| ,, *ventricosa* Kz. | ,, | 1530 |
| ,, *granulata* Kz. | ,, | 900 |
| ,, *Hyndmannii* Sm. | 670 | ,, |
| *Eunotia undulata* Grun. | ,, | 1070 |
| ,, *tetraodon* Ehb. | ,, | 1400 |
| ,, *tetraodon* Ehb. var. *diodon* | ,, | 2100 |
| ,, *tetraodon* Ehb. var. *diadema* | ,, | 2400 |
| ,, *incisa* Greg. | ,, | 1550 |
| ,, *indica* Grun. | ,, | 1200 |
| ,, *prærupta* Ehb. | ,, | 1800 |
| ,, *Soleirolii* Kz. | ,, | 1200 |
| *Synedra thalassiothrix* Cleve (Messina) | ,, | 1370 |
| ,, *sicula* Castracane | ,, | 835 |
| ,, *splendens* Kz. | ,, | 1030 |
| ,, *ulna* Ehb. | ,, | 970 |
| ,, *formosa* Hantzsch. | ,, | 1030 |
| ,, *crystallina* Kz. | ,, | 1200 |
| ,, *pulchella* Kz. var. | ,, | 2150 |
| ,, *tabulata* Kz. | ,, | 1320 |
| ,, *affinis* Kz. | ,, | 1150 |
| *Grammatophora marina* (Kz.) Sm. | 1600 | 1600 |
| ,, *angulosa* Grun. var. | ,, | 1350 |
| ,, *oceanica* Ehb. | ,, | 3850 |
| *Nitzschia formica* Hantzsch. | 1550 | 1550 |
| ,, *linearis* Sm. | ,, | 3000 |
| ,, *amphioxys* Sm. | ,, | 2000 |
| ,, *hungarica* Grun. | ,, | 1800 |
| ,, *sigmoidea* Sm. | ,, | 1070 |
| ,, *spectabilis* (Ehb.) Sm. | ,, | 2750 |
| ,, *dubia* Hantzsch. | ,, | 2000 |
| *Perrya eximia* | ,, | 975 |
| *Mastoglia Dansei* Thw. | ,, | 1450 |
| ,, *meleagris* Kz. var. | ,, | 2000 |
| ,, *Braunii* Grun. var. | ,, | 1850 |
| ,, *marginulata* Grun. var. | ,, | 1600 |
| ,, *exigua* Lew. | ,, | 2600 |
| *Achnanthes inflata* Grun. | ,, | 970 |
| ,, *subsessilis* Kz. | ,, | ,, |
| ,, *longipes* Ag. | 1400 | ,, |
| ,, *brevipes* Ag. | 1100 | 1700 |
| *Cymbosira Agardhii* Kz. | ,, | 1250 |
| *Achnanthidium lanceolatum* Breb. | ,, | 1400 |

| | Longitudinal Striæ per mm. | Transverse Striæ per mm. |
|---|---|---|
| *Cymbella pisciculus* Ehb. | 1100 | 1250 |
| „ *heteropleura* Ehb. | „ | 900–1100 |
| „ *affinis* Kz. var. | „ | 1200 |
| „ *helvetica* Kz. | „ | 1100–1300 |
| „ *scotica* Sm. | „ | 1150 |
| „ *Kamtschatica* Grun. | 1200 | 900 |
| „ *navicula* Ehb. | „ | 1500 |
| „ *cuspidata* Kz. | „ | 1175 |
| *Gomphonema robustum* Grun. | „ | 1230 |
| „ *acuminatum* Ehb. var. *coronatum* | „ | 1100 |
| „ *dichotomum* var. *trigibbum*, Eul. | „ | 1030 |
| „ *capitatum* Ehb. | „ | 1130 |
| „ *commune* Rabh. | „ | 1250 |
| *Rhoicosphenia curvata* Grun. | „ | 1670 |
| *Navicula ambigua*, Ehb. | 2609 | 1900 |
| „ *serians* Kz. | „ | 2200 |
| „ *bohemica* Ehb. | „ | 1700 |
| „ *sculpta* Ehb. | „ | 1450 |
| „ *limosa* Kz. | „ | 1900 |
| „ *quinquenodis* Grun. | „ | „ |
| „ *retusa* Breb. | „ | 650 |
| „ *Reinhardtii* Grun. | „ | 900 |
| „ *slesvicensis* Grun. | „ | 1050 |
| „ *sphærophora* Sm. | „ | 1600 |
| „ *amphisbœna* Kz. | „ (a little irr.) | 1500 |
| „ *amphisbœna* Kz. var. | „ | 1300 |
| „ *permagna* Bailey var. | „ | 1275 |
| „ *firma* Kz. | „ | 1550 |
| „ *firma* var. *affinis* Ehb. | „ | 1900 |
| „ *firma* var. *amphirhyncus* Ehb. | „ | 1570 |
| „ *firma* var. *dilatata* Ehb. | 1650 | 1650 |
| „ *firma* var. *latissima* Ehb. | „ | „ |
| „ *firma* var. *Hitchcockii* Ehb. | „ | 2100 |
| „ *elegans* Sm. | „ | 1425 |
| „ *crassa* Greg. | „ | 1250 |
| „ *quadrata* Greg. | „ | 1500 |
| „ *entomon* Ehb. | 850 | 900 |
| „ *didyma* Kz. | „ | 1000 |
| „ *elliptica* Kz. | „ | 1325 |
| „ *lyra* Ehb. | „ (irreg.) | 700–800 |
| „ *lyra* var. | „ | 1000 |
| „ *major* Kz. | „ | 630 |
| „ *oblonga* Kz. | „ | 850 |
| „ *gibba* Kz. var. | „ | 1000 |
| „ *hemiptera* Kz. var. | „ | 1400 |
| „ *peregrina* Ehb., Sm. | 2400 | 750 |

| | Longitudinal Striæ per mm. | Transverse Striæ per mm. |
|---|---|---|
| *Navicula viridis* Kz. | 2400 | 720 |
| „ *divergens* Sm. | „ (irreg.) | 1100 |
| „ *divergens* Sm. var. | „ | „ |
| „ *stauroneiformis* Sm. | „ | 1200 |
| „ *stauroneiformis* Sm. var. *latialis* | „ | 1900 |
| „ *crassinervis* Breb. | „ | 1400 |
| „ *rhomboides* Ehb. | 1700 | 2400 |
| *Frustulia saxonica* Rabh. | 3600 | 3400 |
| *Scoliopleura convexa* Grun. | 3600 | 700 |
| „ *tumida* (Breb.) Rabh. | „ | 1300 |
| *Pleurosigma balticum* Sm. | „ | 1450 |
| „ *attenuatum* Sm. | 1050 | 1400 |
| „ *hippocampus* Sm. | „ | 1750 |
| „ *formosum* Sm. | 1580 | 1900 |
| „ *angulatum* Sm. | „ | 2080 |
| *Donkinia recta* (Donk.) Ralfs | „ | 2100 |
| *Toxonidea insignis* Donk. | „ | 2250 |
| *Pleurostaurum javanicum* Grun. | 1300 | 1320 |
| „ *acutum* Rabh. var. | 900 | 1300 |
| *Endostaurum crucigerum* (Sm.) Breb. | „ | 1400 |

Mr. F. Kitton makes the following observations on the preceding paper:—"If I understand the author aright, it would seem that it is only when dealing with a series of valves produced by a single germ or sporangial frustule that the striation is constant and that the variation never exceeds $\frac{1}{5}$ in the same species from a different stock. If this means a difference in the number of striæ, the variation is considerable, e. g. it gives a range in *Navicula crassinervis* of 11–14 in ·01 mm. = 27–35 in ·001 inch. Some error must have been made in the measurement of the transverse striæ on the above-named species; the author says they are 14 in the ·01 of a mm. (35 in ·001 of an inch), only 2 more than those on *N. stauroneiformis* Sm., and 10 less than those on *N. rhomboides*, which he says are 24 in ·01 mm., a much easier form to resolve than the form called *N. crassinervis*. *N. limosa* is said to have 19 in ·01 mm., but they are easily resolved with an old Ross $\frac{1}{4}$ objective (75°). *Endostaurum crucigerum* is also stated to have 14 striæ in ·01 mm.; any $\frac{1}{2}$ objective easily resolves both the longitudinal and transverse striæ at the same time. *Nitzschia sigmoidea* Sm., the author says, has 10·75 in ·01 mm.; Smith states them to be 85 (= 34 in ·01 mm.); Sullivant and Wormeley 70 in ·001 of an inch. Professor E. W. Morley * makes them 63 (which is, we believe, accurate). *Nitzschia spectabilis* (= *Synedra spectabilis* of Ehrenberg, and *N. sigmoidea* $\beta$ of Smith), is stated to have striæ as close as 27·50 in ·01 mm. (= 68·75 in ·001 of an inch). Smith says they are 42 in ·001 inch; we make them 35 to 38, an average of 14·5 in ·01 of a mm. *N. amphioxys* Smith, 20 in ·01 mm. Castracane; 15 in ·01 mm. Morley. The measure-

* Mon. Micr. Journ., xv. (1876) p. 227.

ments of Professor Morley were made with great care by means of a Troughton and Sims micrometer belonging to the Hudson equatorial; the objective a Tolles $\frac{1}{16}$, and monochromatic sunlight was used; the measurements were afterwards carefully checked by J. E. Smith, of Ashtabula, U.S., by the camera lucida, and they were found to harmonize.

The great discordance in the number of striæ between the two measurements is difficult to understand. We find in

| | C. | M. | Difference. |
|---|---|---|---|
| *Navicula crassinervis* | 14 | 33 | + 19 |
| *Nitzschia sigmoidea* | 10·70 | 25 | + 14·30 |
| „ *amphioxys* | 20 | 15 | − 5 |
| *Pleurosigma angulatum* | 20·30 | 17 | − 3·30 |
| *Grammatophora marina* | 16 | 14 | − 2 |

This disparity can only be accounted for either by supposing that different forms had been measured, or that one of the systems adopted was not to be depended upon. The former supposition seems the more probable, as some of the measurements agree, or nearly so; e.g. *G. marina* and *Pleurosigma balticum*, C. 14·5, M. 14 nearly. Dr. Woodward * says the number of striæ on *Frustulia saxonica* is 85–90 in ·001 of an inch (34–36 in ·01 mm.); Count Castracane makes them 34 in ·01 mm.

Dr. Schumann, in his 'Diatomeen der Hohen Tatra,' says he found *Navicula rhomboides* with striæ as close as 78 in $\frac{1}{100}$ Paris line; this is equivalent to $87\frac{3}{4}$ in ·001 of an inch, or $35\frac{1}{2}$ in ·01 mm. These numbers agree very well with those on *F. saxonica*."

**Endophytic Algæ.**†—G. Klebs has made a careful examination of a number of the lowest forms of algal life. The first part of his paper has reference to two species belonging to the genus *Chlorochytrium* of Cohn, of which various forms have already been described by Cohn, Kirchner, and E. P. Wright.

*Chlorochytrium Lemnæ* of Cohn was found, as indicated by that writer, within the tissue of *Lemna trisulca*. The external form of the single cell is very variable, spherical, elliptical, lobed, or angular, and it is always found in the intercellular spaces of the subepidermal parenchymatous layer of the upper or under side. The cell-wall is moderately thick, consisting of cellulose, and encloses a delicate green mass of protoplasm, with a few scattered grains of starch and a large vacuole. As it developes, a number of green threads of protoplasm are formed in the interior, which make a beautiful network. Later it becomes filled with large starch-grains, is denser, and assumes the appearance of a dark green coarsely granular mass. In this state it may remain for weeks, until the period of formation of the zoospores, which is always the close of the normal life-history. From the endophytic character of the alga, its great delicacy, and the dark colour and density of its contents, the formation of the zoospores is very difficult to observe. The author

* 'Lens,' i. p. 233.

† Bot. Ztg., xxxix. (1881) pp. 249–57, 265–72, 281–90, 297–308, 313–19, 329–36 (2 pls.).

has nevertheless determined that they are the result of repeated bipartition of the protoplasm, the whole process taking four or five days. Before escaping, the biciliated zoospores are always surrounded by a gelatinous mass, the whole mass rupturing both the cell-wall of the *Chlorochytrium* and the tissue of the *Lemna* before the zoospores are endowed with motion. While still enclosed in the jelly, the zoospores are seen to unite in pairs by their apices into an hourglass-shaped body, in which condition they whirl rapidly round one another, and then coalesce into a nearly spherical zygozoospore. These finally with their apices bore through the gelatinous envelope, and move about freely by means of their four cilia. Some, however, never succeed in breaking through the envelope; this at length disappears, as do those which, after moving about, do not come in contact with *Lemna*. Klebs was not able to detect the tubular processes described by Cohn, by means of which the zoospores escape, nor the two kinds of zoospore which Wright describes. The zygozoospores settle on the epidermis of the *Lemna*, always at the point of junction of two cells. When come to rest they are always already enclosed in a cell-wall. After from one to three days, they begin to penetrate by forcing apart the two cell-walls of the epidermis, and develope into a new individual beneath it. When the host decays or falls to the bottom of the water, these individuals remain in the resting state in which they persist through the winter, and in the spring develope from their contents new zoospores.

*Chlorochytrium Knyanum* is endophytic in *Lemna minor* and *gibba*. The structure and course of development are in the main the same as in *C. Lemnæ*, but the zoospores differ somewhat in shape, and no conjugation of them was observed, either while within the gelatinous envelope or when moving freely in the water. They eventually come to rest, and penetrate the epidermis of the host. They develope into a resting condition within its tissue, and in the spring again develope non-sexual zoospores by bipartition. In addition to the hosts above mentioned, this species was also observed in *Ceratophyllum demersum* and *Elodea canadensis*, but never in *Lemna trisulca*.

*Endosphæra biennis* is a hitherto undescribed organism, nearly allied to *Chlorochytrium*, found in the form of large green resting-cells in dead leaves of *Potamogeton lucens*. The cell-wall is remarkably thick, and evidently composed of two layers; the contents are protoplasm coloured by chlorophyll, containing also a colourless oil and numerous small starch-grains, with a clearer space in the centre. When ready to germinate, these divide by repeated bipartition into a number of daughter-cells, each enclosed in a delicate cell-wall of cellulose, the whole at the same time increasing in size. In each of these daughter-cells is now formed, by renewed bipartition, a small number of small spherical zoospores. The whole mass now escapes entire from the host; the zoospore breaks through the cell-wall of the daughter-sporangia, and the gelatinous envelope of the whole then disappears. The escaped zoospores are pear-shaped, about $6 \cdot 2\ \mu$ long and $4 \cdot 9\ \mu$ broad, biciliated, and copulate by their apices into a quadriciliated zygozoospore. These invariably perish, unless

they meet with living leaves of *Potamogeton lucens*, which they penetrate in the same manner as *Chlorochytrium Lemnæ*, forming resting-cells within the tissue. These appear always to hibernate before again developing into zoospores.

*Phyllobium dimorphum* is another hitherto undescribed form, endophytic in the leaves of *Lysimachia nummularia*, and occasionally in *Ajuga reptans*, *Chlora serotina*, and *Erythræa Centaurium*. The resting-cells are very large, causing wart-like protuberances in the leaves of the host. They are of two kinds; the larger ones have a very thick cell-wall, and peculiar tubular appendages at one or both ends; the smaller ones have no such appendages. The cell-wall of the larger cells is as much as 0·018 mm. in thickness, and is evidently composed of two layers. It encloses a green protoplasm with a large roundish nucleus, and a great quantity of starch, and a yellow or red oil of peculiar properties, called by Cohn *hæmatochrome*. Under certain circumstances they contain peculiar, roundish, flat corpuscles, the function of which is obscure. For the production of zoospores, small masses of protoplasm are first formed within the resting-cells, from each of which is developed a small number of zoospores. At the period of ripeness a particular point of the cell-wall of the resting-cell gelatinizes, and through this opening the masses of protoplasm force their way with beautiful regularity, the zoospores thus becoming free. They are biciliated and of two kinds, alike except in size; the smaller ones being about 6·8 $\mu$ long and 5·7 $\mu$ broad, the larger ones 8·2 $\mu$ long and 7·0 $\mu$ broad. These always perish unless they conjugate. They appear only to arrive at a conjugating condition after moving about for a time. This always takes place between one of each kind, the larger one remaining passive during the process, the smaller one moving rapidly round it, then bringing its apex into contact with the colourless apex of the other, and finally entirely coalescing with it. The resulting zygozoospore has, as a rule, only two cilia. The author never observed conjugation between two zoospores of the same kind, nor between two from the same sporangium. Zygozoospores with four cilia were occasionally seen, which may be the result of the conjugation of two macrozoospores; they are about 11·8 $\mu$ long and 8·8 $\mu$ broad. As soon as they come to rest they become invested with a cell-wall, and then begin to put out a germinating tube, which sometimes branches and assumes a great variety of forms. By means of these tubes they penetrate the tissue of the host, especially in the neighbourhood of the veins of the leaves, developing among the spiral vessels by apical growth, sometimes to a length of several centimetres. To form a resting-cell, the tube swells up at a particular spot, where the protoplasm congregates from the various branches, this portion of the tube finally becoming separated and rounded off. Whether more than one resting-cell is ever developed from the same tube was not clearly determined. The smaller resting-cells are found beneath the epidermis, in the neighbourhood of the stomata, either singly or in numbers; they are much smaller than the large ones, and appear to produce macrozoospores only, between which conjugation was never observed. In some cases they

came to rest, invested themselves with a cell-wall, and germinated like the zygozoospores, putting out germinating tubes.

*Phyllobium incertum*, a nearly allied species, occurs in dead leaves of Gramineæ and Cyperaceæ. The resting-cells are of a bright red colour, owing to the chlorophyll being more completely changed into hæmatochrome. No conjugation of zoospores was observed; and it may be only a small non-sexual condition of the other species.

Large green resting-cells found in dead branches and leaves of a species of *Hypnum* were referred by the author to yet another species and genus, *Scotinosphæra paradoxa*. They were of essentially the same structure as the resting-cells of two species of *Phyllobium*; but the mode of formation of the zoospores presents a remarkable difference. The entire protoplasm of the resting-cell becomes extremely finely granular, the hæmatochrome entirely disappearing. A variety of changes take place in the protoplasm, resulting in the formation of a dark bluish green spherical mass, surrounded by a protoplasmic fluid which is filled with red granules. The central mass gradually enlarges, and divides into two and then into four; and then still further by repeated bipartition; finally resulting in the production of zoospores, which are narrowly fusiform, about $9 \cdot 3\ \mu$ long and $3 \cdot 1\ \mu$ broad, with a long colourless apex to which are attached two cilia. No conjugation of zoospores was observed; they round themselves off and become invested with a cell-wall; the subsequent development of the resting-cells requires further investigation. A very similar structure was also found endophytic in *Lemna trisulca*, which may probably be a variety of the same species. It is probably altogether non-sexual; or conjugation of zoospores may possibly take place on the close of a number of non-sexual conjugations.

Dr. Klebs points out the transition from *Phyllobium*, in which conjugation takes place only between zoospores from different cells, to *Chlorochytrium*, in which the two sexual cells result, by bipartition, from the same mother-cell, and which probably represents the simplest form of sexual reproduction.

The author disputes the correctness of the term parasitic applied to these or similar endophytic algæ by Wright, Archer, Reinke, and others. They invariably contain chlorophyll, and always live so near the surface of the host that abundance of light can reach them. Their object in penetrating the tissue of aquatic and other plants is merely to find a favourable situation for the development of their resting-cells.

The forms now described must evidently be classed under the Protococcaceæ; and the following may be given provisionally as their diagnoses:—

*Chlorochytrium* Cohn. Each cell breaks up, by repeated bipartition, into spherical zoospores, which, escaping from the mother-cell, conjugate within the surrounding gelatinous envelope; the zygozoospores, already enclosed in a cell-wall, penetrate the intercellular spaces of living plants by means of a germinating tube. During the period favourable to growth several generations succeed one another in one year, the latest hibernating in a resting state.

*C. Lemnæ.* Inhabits the large intercellular spaces of the parenchyma of *Lemna trisulca.* Cells usually spherical or elliptical; that part of the germinating zygozoospore which remains outside the epidermis becomes a spherical head of cellulose.

*Endosphæra.* Each cell breaks up by repeated bipartition into a number of daughter-cells surrounded by a cell-wall, out of which the spherical zoospores are formed by further bipartition. On escaping, those from the same mother-cell conjugate, and, like those of *Chlorochytrium*, penetrate the living tissue of the host. The zoospores are formed only in the spring; the new generation takes a full year to mature.

*E. biennis.* Inhabits the intercellular spaces of the subepidermal parenchyma of leaves of *Potamogeton lucens.* Cells usually spherical; the part of the germinating zygozoospore which remains outside the epidermis dies off quickly.

*Phyllobium.* At the time of maturity the green protoplasm of each cell is differentiated into cylindrical or spherical portions, which become transformed into smaller ones, and coalesce to form zoospores. These are of two sizes, macrozoospores and microzoospores; the resulting zygozoospores penetrate the stomata of the living or dead leaves of flowering plants. Each cell takes a year to mature.

*P. dimorphum.* Inhabits the leaves of *Lysimachia nummularia*, *Ajuga*, *Chlora*, &c. The zygozoospores put out germinating filaments, which grow in the vascular bundles of the leaf-veins into branched green tubes; the protoplasm of each of these tubes congregates into a spherical or elongated resting-cell, which hibernates, giving rise to sexual zoospores in the next summer. According to external circumstances the development of the germinating filament varies greatly; it may be quite rudimentary, when small resting-cells are formed without any filaments, which give rise to non-sexual zoöspores.

*Scotinosphæra.* When mature the green protoplasm of each cell is differentiated into cylindrical or spherical portions; these coalesce, with the elimination of a red granular substance, into a single spherical mass of protoplasm; this divides by repeated bipartition, the granular substance being again absorbed, into zoospores, which are non-sexual, and penetrate the dead tissue of the host. The course of development occupies a year.

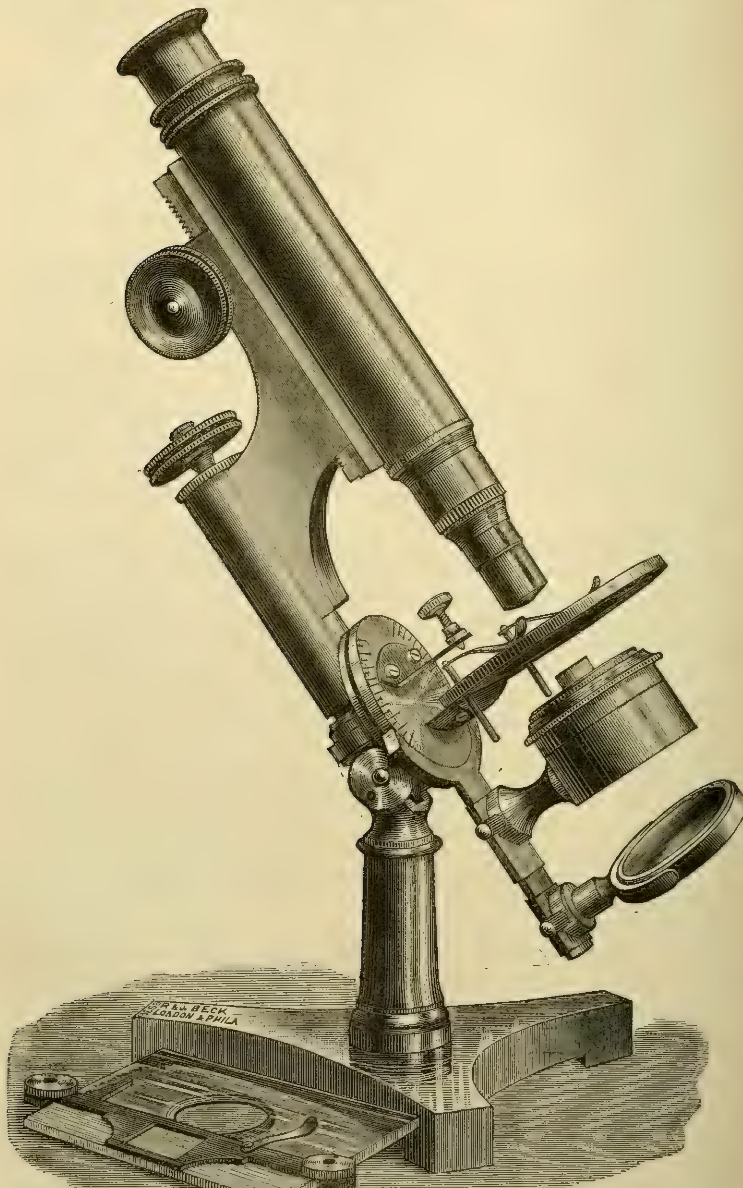
*S. paradoxa.* Inhabits dead or dying tissues of *Hypnum* and of *Lemna trisulca.* Cells usually spherical; zoospores fusiform.

## MICROSCOPY.

### α. Instruments, Accessories, &c.

**Beck's "Ideal" Microscope.**—In this instrument (shown as a monocular in Fig. 166) the *stage* is of very thin and stiff brass with

Fig. 166.



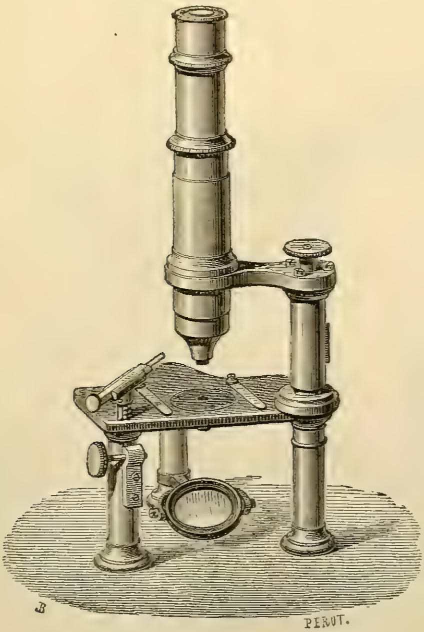
a large opening, and provided with reversible spring clips so as to attach an object to the under side if required. To the stage can be adapted either a circular stage-plate of thin sheet brass revolving concentrically, or the glass stage-plate shown in the figure, with brass object-carrier, and allowing 1 inch of movement in all directions.

The mirror and substage slide upon a *swinging tail-piece*, the latter being attached to a graduated circle, and allowing wide range of motion above and below the stage.

The body draws out to the standard length (10 inches), and takes full size eye-pieces. It has an adapter for the broad-gauge screw. When fully extended it is 15 inches in height, or can be reduced to 11 inches.

**Cosson's "Dissecting" and "Observing" Microscope.**—This (Fig. 167) can be used either as a simple or compound Microscope. It consists of a stage, 13 cm. wide, supported on three pillars. In

FIG. 167.



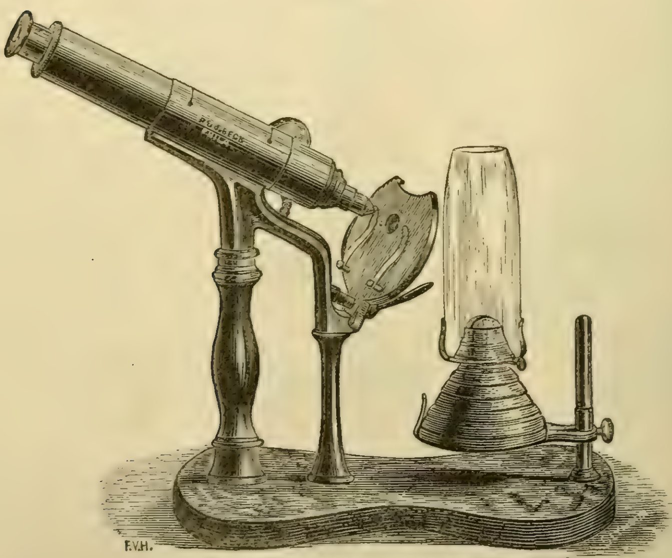
one of the two anterior pillars is a vertical support (raised or depressed by rack and pinion), carrying a sliding arm for the doublets, &c. The other pillar supports the elbow-piece to which the compound body is fixed. The vertical part of the elbow-piece consists of two tubes forming the ordinary Continental fine adjustment, and the whole can

be firmly fixed by a tightening screw, or can be turned aside, or removed altogether, when it is desired to use the instrument as a simple Microscope. The mirror is attached to the third pillar.

**Holmes's Class Microscope.**—This instrument (Fig. 168), the design of Dr. O. W. Holmes, of Boston, U.S.A., is substantially a modified form of Beale's Demonstrating Microscope, except that the tube is not in a horizontal but in a suitably inclined (fixed) position. The wooden pillar on the left forms the handle for passing the instrument round the class. The coarse adjustment is effected by sliding the body through the outer split tube. The height of the instrument is about 12 in., and the size of the base (on which it stands for ordinary table use) 12 × 4 inches.

A special peculiarity is in the fine adjustment, which is effected by moving the stage. For this purpose the stage is suspended by its lower edge to a metal hinge. A somewhat coarse-threaded screw attached to the limb, and having a strong spiral spring coiled round

FIG. 168.

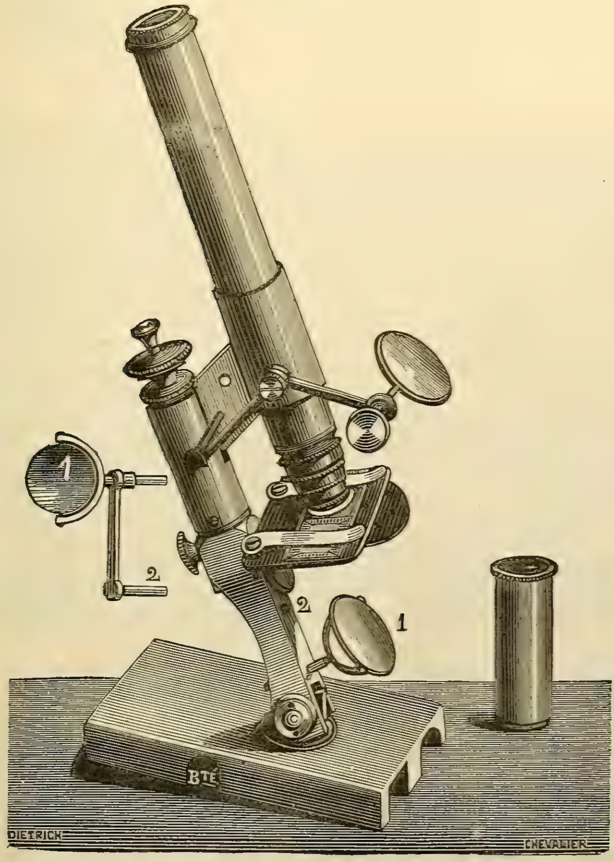


it, passes through the stage, and is acted upon by the nut with lever-arm seen beneath. The lateral movement of this lever-arm in one direction causes the stage (which is held between the spiral spring above and the nut beneath), to tilt up from the hinged joint, the spring forcing the stage back again when the lever is turned in the reverse direction. The motion is therefore not strictly at right angles to the optic axis, but for low-power work this is hardly of consequence. In lieu of a con-

densing lens for opaque illumination, a mirror with three arms, joined by ball-and-socket movements, is attached to the limb. The ring which carries the lamp can be variously adjusted on the standard, to suit the convenience of observation.

**Pocket Microscope.**—Figs. 169 and 170 show a compact form of compound Microscope (of anonymous French origin) which may be commended for its portability.

Fig. 169.

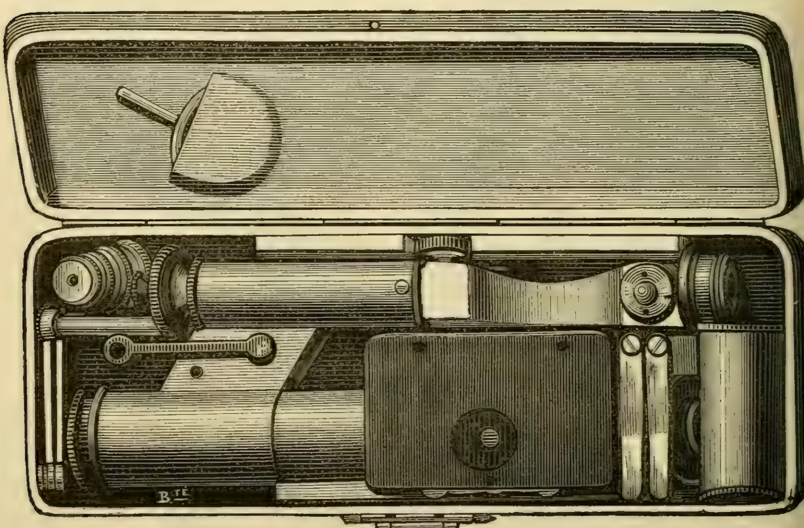



The base is a substantial metal tablet upon which the instrument is screwed (Fig. 169). A cradle joint just above the base permits inclination, and in all positions the Microscope is quite steady. The coarse adjustment is effected by sliding the tube and the fine adjust-

ment by the usual screw acting against a spiral spring in the hollow limb, as generally adopted in Continental models. The draw-tube is graduated. The mirror (1) can either be used in the optic axis as shown *in situ*, or an additional elbow-piece (2) fitting into the hole (2) immediately below the stage can be made use of for giving some range of obliquity. A condensing lens for opaque illumination, fitted with jointed arms, can be attached to the side of the tube, and a revolving plate of diaphragms beneath the stage.

For convenience of packing the objective is removed, the draw-tube closed, and the optical body drawn up the sprung-socket; the milled head shown behind the limb is then partly unscrewed, allowing the stage to be turned laterally a quarter-turn, so that it lies parallel with the limb, the optical body being slid down again as far as it will

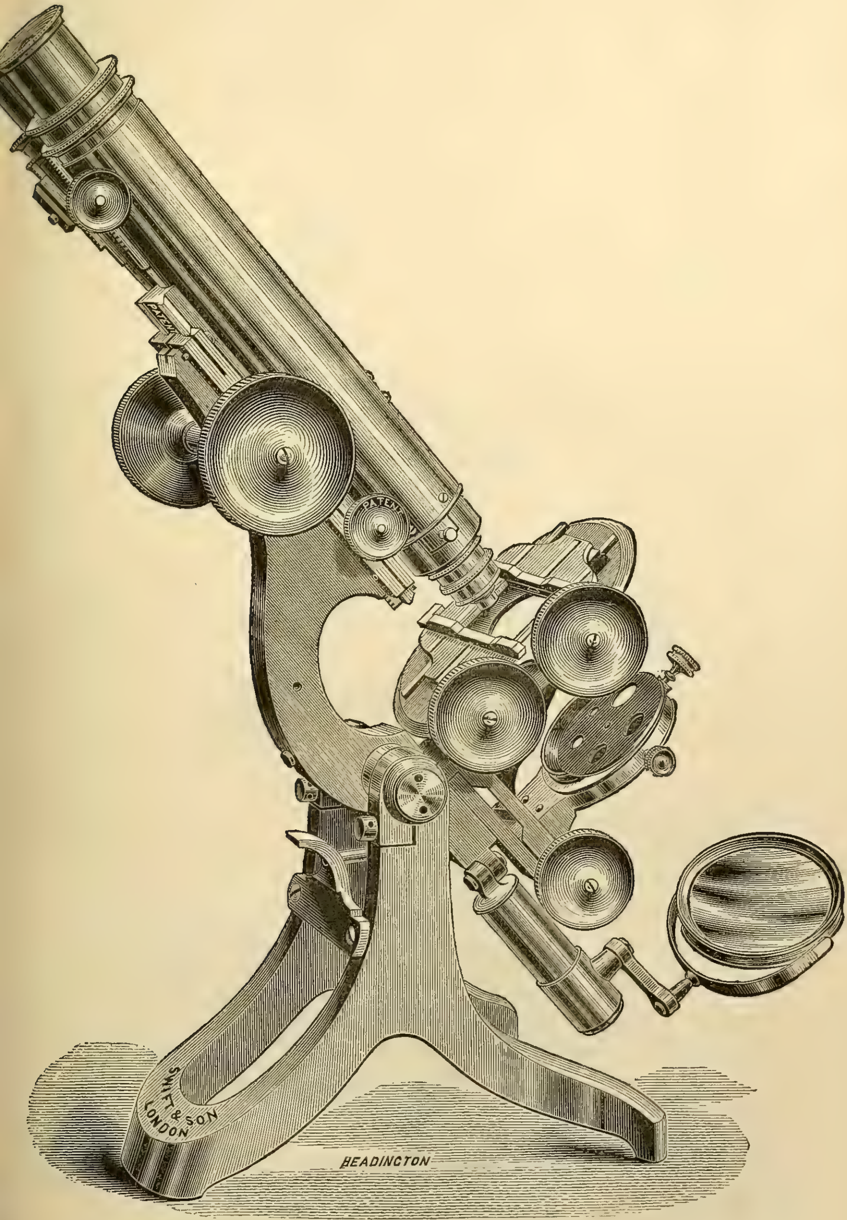
Fig. 170.



go. The mirror and condensing lens are also removed, and the base unscrewed, inverted, and placed in the travelling case, the under surface—shaped in the casting—forming a secure packing for the instrument as shown in Fig. 170. The whole is enclosed in a leather-covered box $7\frac{1}{2} \times 3 \times 1\frac{3}{4}$ inches (about the size of a cigar-case), which can be used as the foot, the Microscope being screwed to the lid instead of the metal base, if it is not desired to be encumbered with the latter on excursions, &c.

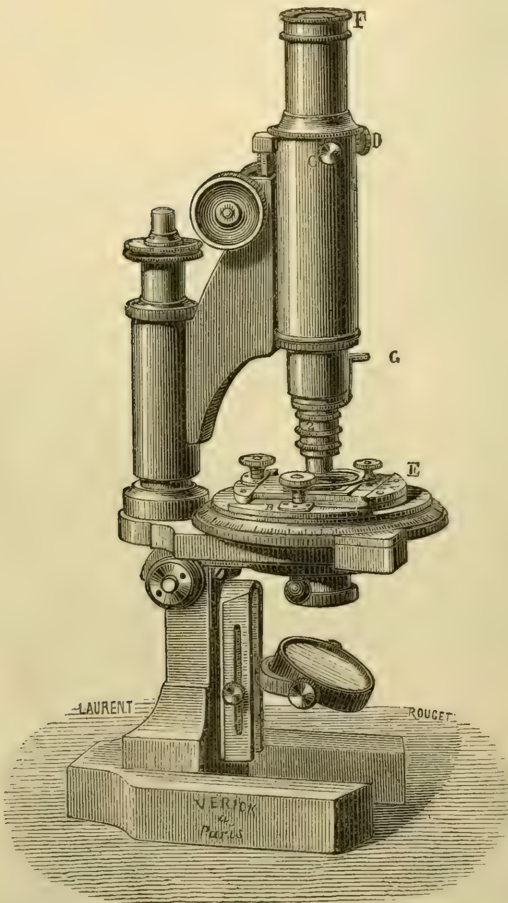
Swift's "Challenge" Binocular Microscope (C).—This form of stand (Fig. 171)—the type model of Messrs. Swift and Son—has had their fine adjustment (described *ante*, p. 296) adapted to it, in which

FIG. 171.



the lifting power is central to the line of motion, thus preventing any tilting. A new mechanical stage of extreme thinness has also been added, the decrease of thickness having, it is claimed, been obtained without any reduction of the solidity possessed by the former stage, as it will bear manipulation of the movments and ordinary touch of the fingers without showing any signs of deflection. The stage allows of an inch of rectangular motion.

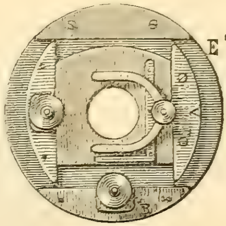
FIG. 172.




**Verick's "Goniometrical Microscope for Mineralogy."**—The general design of this instrument (made in 1879) is shown in Fig. 172, but the following specialties may be noted:

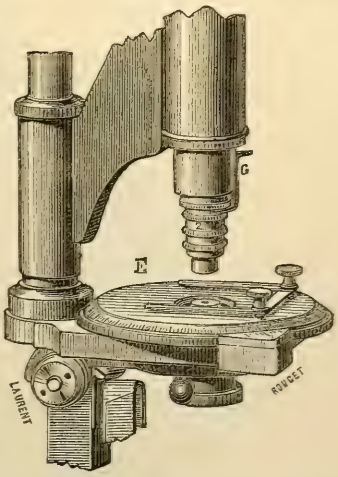
The *mechanical stage* (E′, Fig. 173 and E, Fig. 172), which is attached at pleasure to the ordinary stage (shown in Fig. 174 E) when the clips are removed, appears to be an anticipation in principle of those of Tolles and Watson* recently introduced, the rectangular movements being controlled on the surface by two milled heads acting entirely within the circumference. B (Fig. 173), and the opposite symmetrical piece are attached to the fixed bottom plate and have V-shaped grooves between which the movable plate A slides. Rackwork is cut on the lower edge of the latter, which is acted upon by a pinion (milled head shown at B) giving about one inch of motion. The plate A has in the same way two opposite symmetrical pieces similarly grooved, and an upper movable plate slides between them by rack and pinion motion (milled head shown on the left) acting at right angles to the former motion. This upper plate is provided with an angle-piece serving as a stop for the object, and a sprung "horse-shoe" clip for holding the object in place. At A and B are graduations for use as finders.

Fig. 173.




The bevelled edge of the *rotating stage* (Fig. 174) is graduated, and a vernier is placed on a projecting angular piece for convenience of reading the angle. The diaphragms slide from beneath the stage into a cylindrical tube, and can be used flush with the surface of the stage.

Fig. 174.




The *mirror* can be raised or lowered, and swung laterally by the arrangement shown in Fig. 172.

The eyepiece-tube can be exactly centered by the screws C and D (Fig. 172), which is of advantage in the determination of the polarizing axis in minute crystals.

When the instrument is required for ordinary investigation the eyepiece-tube is replaced by a draw-tube of the usual construction. The mechanical stage is also removed, being held in position by two pegs of brass simply fitting into corresponding apertures in the ordinary stage E (Fig. 174) and the sprung stage-clips are substituted.

The Microscope is provided with a novel arrangement termed an "*extractor*," for facilitating the rapid removal and change of objectives at the nose-piece, shown in Figs. 172 and 174 G, and described *ante*, p. 662.

* See this Journal, *ante*, pp. 116 and 300.

**Seibert and Kraft's Dissecting Microscope.** — Dr. Carpenter figures this instrument,* which he commends in preference to those forms in which the supports for the hands are attached to each side of the stage, "an arrangement which is subject to the disadvantage

Fig. 175.

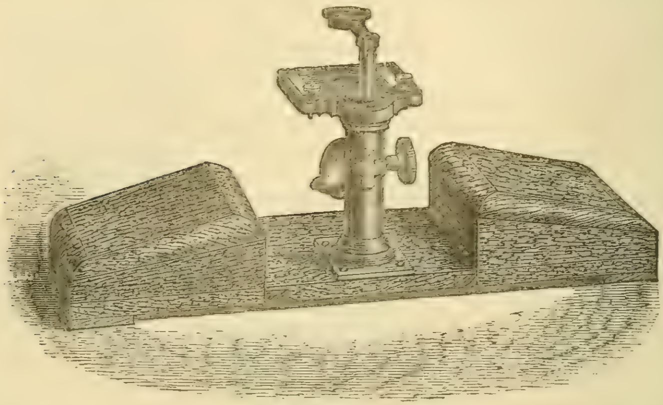
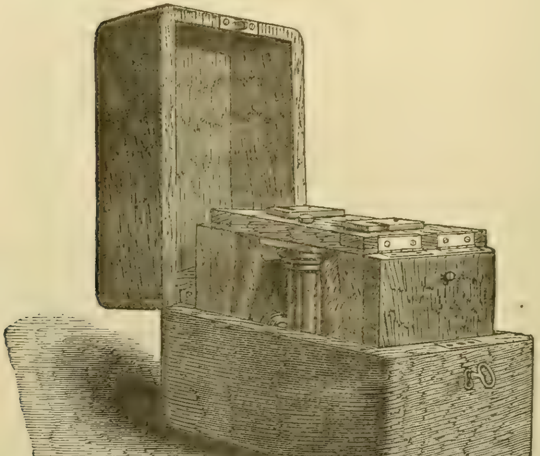


Fig. 176.

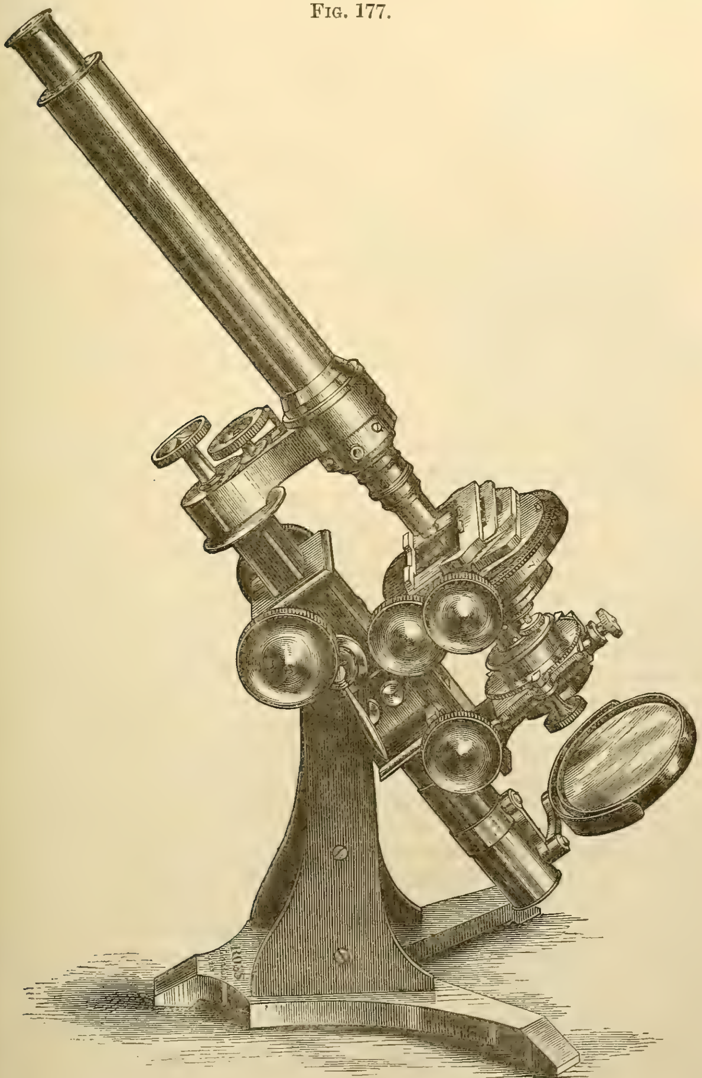


of causing the whole weight of the hands to bear upon the stage so as by depressing it to throw the object out of focus unless the stage be made of extraordinary solidity or be supported in front as well as behind."

* 'The Microscope,' &c., 6th ed., 1881, pp. 54–5 (2 figs.).

Fig. 175 shows the Microscope as opened for use. The oblique wooden blocks, which form the supports for the hands, being hinged to the wooden base of the pillar, can be turned up for portability (as shown in Fig. 176), so that the instrument packs into a very small compass.

FIG. 177.



The Battle of the Stands.—It has hardly yet been generally recognized that the old battle between the "Jackson model" and the

"Ross model" is virtually at an end, in consequence of a discovery which had not been made when the question originally arose.

The advantage of the Jackson model was the increased steadiness which was obtained by the support given to the body-tube throughout the greater part of its length, a support which was wanting in the Ross model.

The advantage of the Ross model consisted in the greater efficacy of the fine adjustment, which could be worked by a relatively long lever, instead of being confined, as in the Jackson model, to a very short one in front of the lower end of the body-tube.

The invention of the method of fine adjustment by which the whole of the body-tube is moved and not merely an inner tube, carrying the objective at the end of the body, at once deprived the Ross model of the advantage which it previously possessed, and left the Jackson model necessarily the preferable form.*

The Ross model is no longer made by the firm whose name it bears, but it has in its day enjoyed so much celebrity, that in order to record it for future reference we print here a figure of it (Fig. 177) which has not previously appeared in the pages of this Journal or its predecessors, other than in the advertisement covers, which are but rarely bound up.

**Fine Adjustment by the Eye-piece.**—Professor L. Ranvier recommends† that the eye-pieces of monocular instruments should be capable of being moved up and down in the draw-tube for the purpose of focussing with high powers. The difficulty of observing with such powers and the fatigue which results are due in great part to the difficulty of exactly focussing the object. The eye of the observer attempts to complete what is wanting in the instrument, and to accommodate itself as much as possible, and it is this fatiguing effort of accommodation which is avoided by the movement of the eye-piece. Apart from the fact that the movement of the eye-piece obviates the necessity for great care in focussing, so as not to displace the image or break the cover-glass, it is a great advantage that with the very exact focus which can thus be obtained it is much easier to determine the superposition of the planes in the case of very small objects—for instance, whether a fibrilla close to a cell passes below or anastomoses with it. As the eye-piece must be very appreciably displaced to very slightly change the point of distinct focus, we "are able to resolve very easily a series of hitherto disputed problems."

The apparatus which Professor Ranvier uses is shown in Fig. 178. It consists of two brass rings *a* and *b*, united by the rackwork *c*, so that the distance between the rings can be increased or diminished. The ring *a* is fitted to the top of the tube of the Microscope, the eye-piece is placed in *b*, and by turning the milled head *d* the eye-piece

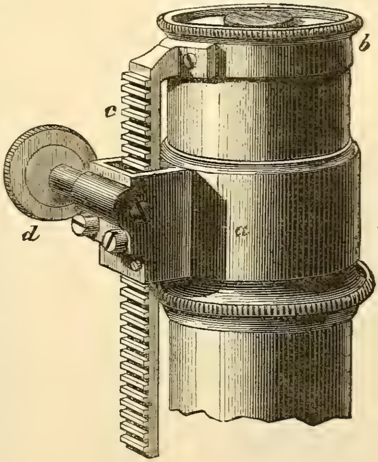
* Dr. Carpenter "feels assured that the principle of supporting the body along a great part of its length (which may be applied in a variety of modes) will in time supersede that of fixing it by its base alone, which is obviously the mode *least* adapted to prevent vibration at its ocular end."—'The Microscope,' &c., 6th ed., 1881.

† 'Traité technique d'Histologie,' Part 1, p. 11. (8vo, Paris, 1875–8.)

can be raised or depressed. With a No. 10 immersion of Hartnack, for instance, a change in the image obtained with $\frac{1}{20}$ or $\frac{1}{50}$ of a turn of the ordinary focussing screw is accomplished only by a whole turn of the milled head *d*.

Mr. J. Deby* has also recently made a somewhat similar suggestion; he says: " When allowing all but adepts in the use of the Microscope to peep through my high-power glasses, I have often felt a certain degree of uneasiness, not to say of alarm, regarding the fate of valuable test-slides, or still more valuable objectives. Many others have no doubt experienced the same discomfort, which I find an easy matter to attenuate to a considerable extent, by focussing from the eye-piece instead of from the coarse or the slow motion. All that is needed for this is a rack and pinion to the eye-piece of considerable length. An inch or two up or down corresponds here to a fraction of a turn of the fine adjustment of the Microscope, so that very little danger exists of any sudden contact with the cover-glass. As soon as an indistinct view of the object is obtained through the ordinary coarse adjustment of the microscope-body, the focus is brought to exactness by means of the coarse motion of the eye-piece without much difficulty. For demonstrations or exhibitions in public, Microscopes could thus be made without the ordinary fine motion."

Fig. 178.




At the June Meeting of the Society, at which Professor Ranvier's plan was discussed, some objection was made to it† and we have since received the further objections as follows:—

" (1) With a high power of large aperture a slight alteration in the length of the body will spoil the definition.

" (2) There is a difficulty in ascertaining the best focus, and the eye is strained in attempting to help in focussing, particularly in focussing *down*. An object should always be observed at the *longest* focus.

" (3) The alteration in power is apt to be misleading, in examining the upper and lower planes."

In any case we should prefer the mode of raising and depressing the eye-piece adopted with English binocular Microscopes. It should also be noted that to utilize the movement of the eye-piece for accurate focussing, there should be a *normal* position from which *upward* and *downward* motion can be made.

* Journ. Quek. Micr. Club, vi. (1880) p. 165.

† See this Journal, *ante*, p. 715.

**Zeiss's Camera Lucida with Two Prisms.**—This camera lucida * (Figs. 179 and 180) consists of a rectangular and an equilateral prism, so combined in the mounting that the image of the pencil and drawing paper is totally reflected twice, and is thus viewed erect by the eye looking over the edge of the equilateral prism at the image produced by the eye-piece of the Microscope.

P (Fig. 180) shows the direction of the ray from the drawing-board; after two reflections this ray emerges parallel to the optic axis of the Microscope. As the angle between the two reflecting

Fig. 179.

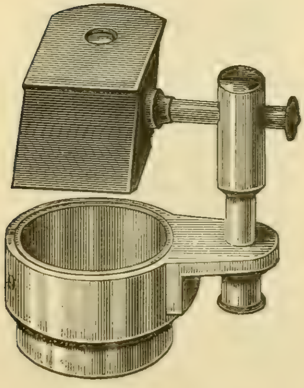
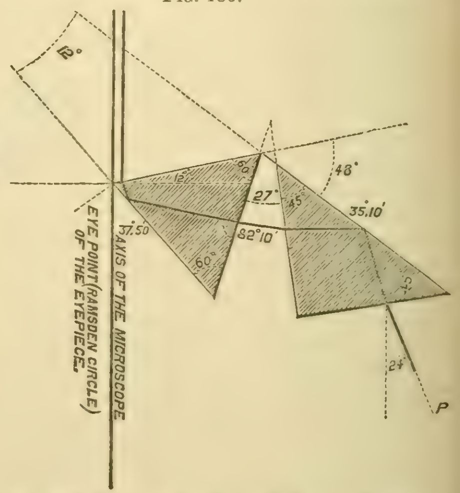


Fig. 180.




surfaces of the prism = 12°, the direction P must always be inclined 24° to the axis of the Microscope. If, in drawing with the prisms, the plane of the paper were horizontal and the Microscope in a vertical position, the drawing would be somewhat distorted, the circular field being projected as an ellipse whose axis would be as 10 : 11. By inclining either the Microscope or the plane of the drawing about 12° the amount of distortion is hardly perceptible. To obtain a strictly similar projection the inclination should be 24°.

The inclination of the upper surface of the equilateral prism (which is supposed = 12° in the diagram) may be varied within certain limits. An angle of 10° to 15° is necessary in order to have total reflection in this prism for all directions within the range of the microscope-field.

The following description of the use of the apparatus is furnished by M. Zeiss:—

"To draw with the prism remove the eye-piece (after exact adjustment of the object) and slide the ring, found under the prism, over the tube of the Microscope, then put the eye-piece again in place.

* This is sometimes known as the "Vertical Camera Lucida," as it is used with the Microscope in an upright position.

The light can fall either on the left or in front. Now turn the ring of the prism to the left, lift the vertical pin sufficiently so that the prism can be placed in a horizontal position over the eye-piece, and push the horizontal pin in so far that the circular opening of the prism is over the centre of the eye-piece. Now place behind the Microscope a drawing-board, or an atlas with the hinge or back touching the foot of the instrument, or about 2 inches away from it, whose upper cover can, by some contrivance placed within it, be inclined about 18°. On this the drawing-paper is to be laid. If the prism has been placed with the horizontal surface so far round the vertical pin backwards that the clear circle visible in the eye-piece, on looking through it from a vertical direction, is about halved by the sharp edge of the prism, we see through the half of this circle which is visible through the prism, not only the object clearly, but also the paper with the pencil. If the further margin of the field of view appears somewhat less clearly on the paper, lift the anterior part of the prism by turning it on the horizontal pin until it is clear, whereupon by depressing the vertical pin the prism is placed as near the eye-piece as possible. In order, however, that both images shall be equally clear it is necessary that both should be equally illuminated. If the pencil-point appears faint and dim, either the paper must be more strongly illuminated by changing the position of the whole apparatus, or the object must be darkened by altering the mirror, and *vice versâ*. Short-sighted people must use a lens when the distance of the pencil is greater than that of their natural vision."

Silver Films for Instruments of the Camera Lucida Class.*—Mr. J. C. Douglas, Secretary and Treasurer of the Asiatic Society of Bengal, in a paper on this subject, points out that what is required in an instrument of this kind is the brilliancy and clear definition of the camera lucida, combined with the simplicity and ease in use, and the cheapness, of the tinted plane glass reflector, with the facility when desired for using two reflections, in order that the reflected image may not be reversed, and he believes these requirements are attainable by the use of silver films on glass.

"These are so highly reflective that two or more successive reflections may be used if desired; by transmitted light the colour of the film is suitable for tinting the glass. The thickness of the film may be regulated according to requirements, a thick film being used when reflection only is required, and a thinner one according to the ratio desired between the reflected and transmitted light. The reflective power of the thinnest film is greatly superior to that of glass. The silver film is applicable to most forms in use, and it may be used not only on plane but on curved surfaces, e. g. a plane concave lens, silvered on the plane side, might be used by a short-sighted person instead of the common plane reflector used in sketching microscopical objects, a slight curvature of the first or second reflecting surface in the camera lucida might be used to render it unnecessary to employ a lens to equalize the sensibly different distances of the images of the

* Proc. Asiat. Soc. Bengal, 1880, pp. 73–6.

object and plane of delineation. The cost of silver films on glass is very trifling, and if taken care of they last for years; a number might be made at intervals, or they might be supplied for a trifling sum by the opticians.

"For many purposes the films might be deposited on thin glass, and varnished or protected by glass, when they would be very durable, and would bear handling. For some purposes the film might be thickened by electro deposition, and removed from the glass. As the films are so cheap, a number of graduated thicknesses might be kept, and a suitable one selected in each case to adjust the relative brilliancies of the reflected and transmitted light; or the films might be applied as the dark glasses usually supplied with the camera lucida, but this seems less simple and convenient than the use of a thicker or thinner film as transmitting reflector. A silver surface may reflect upwards of 90 per cent. of the incident light; a total reflecting prism has been found to reflect only about 75 per cent., or less, the loss being due to reflection at the first surface and absorption; the superiority of the silver surface is evident, particularly when several successive reflections are required. [We understand the fact to be quite the converse, and that the advantage is in favour of the prism.—Ed.] Even if the highest attainable brilliancy be not generally required, still the higher this is, the greater the range of adjustment without alteration of the source of light. The strictest regularity in the film not being essential, suitable films are very readily obtained. With strict cleanliness, pure chemicals, care that the glass is wetted equally in every part by water or alcohol at the moment of immersion in the silvering solution, and care that the solution is properly mixed, i. e. homogeneous, success is readily obtained.

"Professor Govi, of Rome, devised * a form of camera lucida in which a metallic film is used. He simply gilds the reflecting surface of the camera lucida prism with a thin film of gold, and cements to this surface with Canada balsam another similar prism. M. Nachet has adopted this improvement in the construction of various forms of camera lucida. The greater advantages of the silver film are obvious. By the use of silvered glass, instruments of various forms and of large size may be readily constructed for a trifling sum by any ingenious person."

The following is a description of the instruments exhibited at the meeting of the Asiatic Society when the paper was read:—

"1. An ordinary tinted glass reflector for use with the Microscope. The tinted glass usually used was replaced by a piece of glass covered with a thin film of silver. The silvered side is turned towards the eye-piece, and reflects the magnified image. In this form, several reflectors, differing in the thickness of the silver film, should be available for regulating the ratio between the transmitted and reflected light, but a certain thickness of film will be found which is applicable to most purposes, so that change of reflector is seldom necessary.

* See 'Annual Record of Science and Industry,' 1875, p. 144.

2. Camera lucida with double reflection, Fig. 181. The first reflection is from a thick film of silver, the second is from a thinner film. The thickness of the second film may be adjusted as described above. It will be seen that the plane of delineation is seen *through* the second reflector, not past it as in the ordinary instrument. (In the diagrams the thick oblique lines are the silver films, the thin lines the directions of the light, the arrows the objects, and the dotted lines the paper on which the objects are to be drawn.)

FIG. 181.

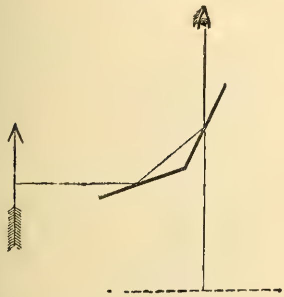
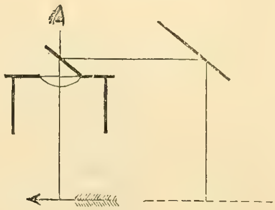


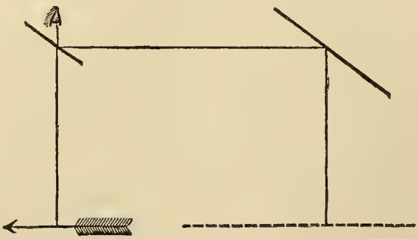
FIG. 182.



3. A form of reflecting camera for sketching microscopical objects, Fig. 182. This instrument being fitted to the eye-piece of the Microscope, the paper and pencil point under the larger reflector appear in the field of the Microscope. The object is seen direct. The second mirror in the instrument exhibited was an inch square. This instrument may be used with the body of the Microscope at any angle, it being merely necessary to place the drawing paper in a plane parallel with that of the microscope-stage. (In the Figs. 182 and 183 the mirrors are represented as parallel; they should usually be slightly inclined to each other, to increase distance between plane of delineation and the object.)

4. Another reflecting camera for sketching small objects is represented in Fig. 183. In the instrument exhibited, the larger reflector was $1\frac{1}{2}$ by $1\frac{3}{4}$ inches and placed 10 inches from the paper; the field was about $4\frac{1}{2}$ inches square. This instrument may be used horizontal or inclined, and it is well adapted for drawing such objects as insects, leaves, shells, &c. If the vertical distances between the mirrors and the object and paper respectively be constant in instruments of this form, the relative magnitudes of object and drawing will obviously vary with the distance between

FIG. 183.



the reflectors. It is evident that by the use of reflectors in instruments of this class, the reflecting surfaces may be larger, and the distance between them greater than if a prism were used.

The above are only examples of the application of silver films to a particular class of instrument; it is evident they offer great facility for giving this class of instrument its maximum development. It is obvious also that silver films are applicable with advantage in many other cases where prisms are used at present, particularly where it is desired to divide a beam of light into two; e. g. if Fig. 183 be turned upside down, and the two eyes of the observer be in the place of the arrow and the dotted line, the diagram represents an arrangement suitable for a non-stereoscopic binocular Microscope, the inclination between the mirrors being varied to suit the distance between the eyes; the loss of light in such an arrangement would be very little, and the brilliancy of the two images might be rendered very nearly equal."

**Apparatus for Examining Different Spectra.**—Whilst the diffraction spectra can readily be seen at the back of the objective by the unassisted eye on removing the eye-piece, they are better defined and their exact arrangement is much better observed by some addition to the Microscope in the form of either an auxiliary Microscope or a telescope.

In the first case, an objective of low power, screwed into the draw-tube, forms, with the eye-piece, a compound Microscope, which can be focussed to the plane of the diffraction spectra. In the second and more convenient arrangement a suitable combination of lenses is placed *above* the eye-piece, as in Ross's "centering glass," forming a *telescope* which can be focussed upon the diffraction spectra in the same manner, and easily removed to substitute other eye-pieces. This plan is the one used for some time by Mr. Ingpen, whose apparatus consists of a Ramsden "positive" eye-piece (formed of two plano-convex lenses of equal focus with the plane surfaces turned outwards) of $\frac{1}{2}$ or $\frac{3}{4}$-inch focus, sliding in a short piece of tube over the lowest power Huyghenian eye-piece. The quality of the illumination, its centricity or obliquity, &c., can also be readily observed in this manner.

**Sorby's Binocular Spectroscope.**—This instrument (Fig. 184), made by Messrs. Beck, was originally described in Proc. Roy. Soc., xv. (1867) p. 433, but has not hitherto been figured. It can be used with the binocular Microscope, and for many purposes is superior to the ordinary micro-spectroscope, and gives a larger dispersion. It consists of the following parts (taken from Messrs. Beck's description):—

1st. An object-glass A, specially arranged, screwing into the tube of the Microscope by the outside screw B.

2nd. A series of compound dense glass prisms C, fitting immediately over the object-glass A.

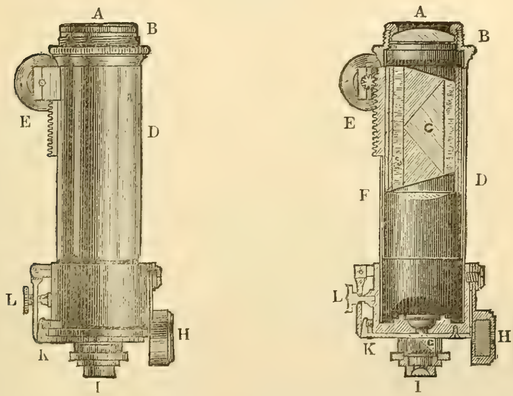
3rd. A tube D, moving up and down upon that holding the prisms by means of rack and pinion E, and carrying the following:—

(*a*) A cylindrical lens F, for lengthening out the spectrum.

(*b*) A small right-angle prism G, sliding in and out of the field of view, which, when slid in, projects over half the field and throws an image of the dark bands in a piece of quartz polarized by means of two Herapathites or flakes of iodide of disulphate of quinine, and termed

(*c*) The "Standard Scale," H. This portion of the apparatus is used when the observer desires to record the position of the absorption bands. The plate of quartz which it contains is cut parallel to the optic axis,* of such a thickness that

FIG. 184.




the line D in the solar spectrum comes between the third and fourth band. It is thus described by Mr. Sorby:—"In order to measure the exact position of absorption bands, &c., seen in spectra, I have contrived a small apparatus which gives an interference spectrum divided by black bands into twelve parts all of equal optical value. It is composed of two Nicol's prisms, or Herapathites, with an intervening plate of quartz about 0·043 inch thick, cut parallel to the principal axis of the crystal, the thickness being so adjusted that the sodium or D line is exactly $3\frac{1}{2}$, counting the bands from the red end towards the blue."

4th. A small lens I, to condense the light from the object. And

5th. A very accurate slit K, one side of which is adjusted by means of the milled head L.

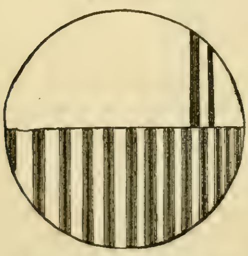
*Mode of Use.*—Screw the object-glass A into the body of the Microscope; slide the rest of the apparatus on, and turn it round

* It is well known that a plate of quartz cut parallel to the optic axis will, under polarized light, give a series of black bands, the distance between such bands being due to the thickness of the plate of quartz.

so that the sides of the spectrum are seen square or upright, thus , not thus . Adjust the outer tube by means of the rack-and-pinion movement E, so that a clear image of the slit K is visible; regulate the width of the slit by the small milled head L, so that if by daylight the more prominent lines in the solar spectrum are seen. Focus the whole body of the Microscope so that the small lens I just touches the object to be examined. (The small lens merely receives the light from the object and does not form an image of it.)

If it is desired to register the position of the absorption bands under view, push in the little prism G at the side, turn down the small box H containing the standard scale, and throw the light through it. In the field of the Microscope will be seen on the upper half the spectrum of the object under observation, and on the under half an image of the standard scale as under, Fig. 185. If the small right-angle prism G should require to be cleaned, it must be withdrawn steadily, to avoid chipping. The carrier is made with a projecting prong *on one side*, which to a great extent protects the prism; but such protection cannot be put on the other side without stopping the light. A piece of black paper has to be cemented on the back of the small prism G, to stop the passage of any direct light. This can be turned up when the prism requires cleaning, which should be done with a delicate piece of wash-leather or cambric handkerchief. If the cylindrical lens F is removed for cleaning, care must be taken in replacing it that the cell is screwed up so that the two marks on the lens are parallel with the slit, otherwise the definition will be impaired.

Fig. 185.



**Fase's Zoophyte Trough, Live Box, or Growing Slide.***—This arrangement, devised by the Rev. H. J. Fase, is shown in plan view with the cover removed at Fig. 186, and in transverse vertical section at Fig. 187. A is a glass plate, 3 inches by $2\frac{1}{4}$ inches, to which is cemented a stout bone or ivory ring B, $\frac{3}{8}$-inch in height, having a thin lining of cork C, cemented to it. D is a shorter tube of ivory or bone, with a broad flange at the top, and closed at the bottom by a disk of thin cover-glass E. This tube D slides freely in B. A narrow slot F is cut in the inside of B, from the top outside, sloping to the bottom inside.

To use the apparatus as a zoophyte-trough, a ring of indiarubber G, cut through as shown at H in Fig. 186, and of a thickness suitable to the object to be examined, is placed at the bottom of B. The object is placed in this ring with a little water, and the cover is then pressed down gently, any excess of water flowing out of the cut in the

* Journ. Quek. Micr. Club, vi. (1881) pp. 249–50 (2 figs.).

indiarubber ring into the box. For use as a growing slide a ring of indiarubber or of gutta-percha tissue is placed as before in the bottom of the box (but in this case the cut in the ring is to be placed as indicated by the dotted lines in Fig. 186); the object to be examined is placed within the ring, and water added through the slot F, which passes into the box outside the indiarubber ring. Water may also be added to supply the loss from evaporation from time to time, through the slot F in the ring B, which slot may be closed by a plug of cotton wool, to exclude dust and prevent evaporation. When it is desired to use the apparatus as a live-box, the indiarubber ring may be dispensed with. The object is placed in the ring B, the cover D pushed in as far as found desirable, and water added if required by the opening or slot F, which may be closed by a plug of cotton wool as before.

FIG. 186.

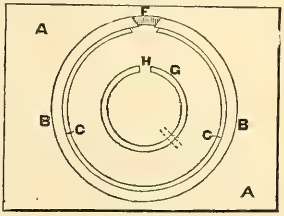
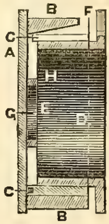



FIG. 187.




The advantages of the apparatus are that it admits of the easy arrangement of the object to be examined; that it is readily cleaned; that as no metal is used in its construction, it allows of prolonged observations being carried on without disturbance of the object; that water, either fresh or salt, may be added from time to time; and that the thin cover-glass permits of high powers being used, and is readily replaced when broken.

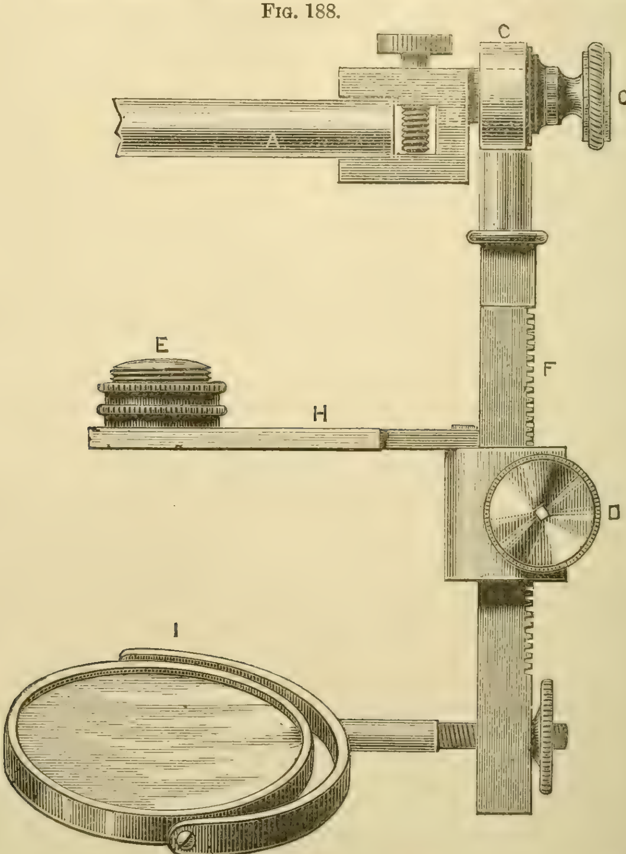
**Malassez's Moist Chamber.***—Professor Malassez recommends a graduated moist air chamber. A thick slide has in its upper surface a circular groove 1·5 mm. broad, 1 mm. deep, and 7·5 mm. in internal diameter. It is pierced outside the groove by three or four holes into which are introduced fine screws; the heads are on the side furthest from the observer (but do not project beyond the lower side of the slide). The points are directed upwards and project so that the cover-glass can be laid upon them; the preparation which is to be examined is placed on that part of the slide which is surrounded by the groove, and by putting some water on the edge of the cover-glass, an air-tight space is obtained without the risk of the water coming into contact with the object, as the groove prevents its passing inwards. By removing the screws any required depth can be given to the space within the chamber, with the aid of a pointer for measuring the depth. By this means the chamber may be utilised for counting (e. g. blood-corpuscles) by given units of space, by having a set of ruled micrometer spaces either on the stage or in the eye-piece.

**Mackenzie's Swinging Substage.**—We briefly alluded, on p. 515, to a simple form of substage devised by Mr. J. Mackenzie, and

* Gaz. Méd., 1879, p. 632. Cf. Zool. Jahresber., i. (1880) p. 25.

referred to the figure of the appliance given in the Journ. Quek. Micr. Club, vi. (1880) pl. xii. Certain modifications have been suggested * which add to its efficiency, and which we here describe with reference to Fig. 188. These modifications are four in number. (1) The application of metal jaws for clamping the swinging bar to the stage at

Fig. 188.




pleasure, instead of the permanent fitting in one position by screws. (2) The *sliding* movement on the arm H, instead of a fixed arm carrying the condenser. (3) Similar sliding movement to the mirror. (4) The rackwork is carried much higher up the bar for greater convenience of focussing the illumination with a condenser of short focal length.

A is a part of an ordinary fixed stage of a Microscope. B, metal jaws clamping upon the edge of A by means of the milled head shown above; the fitting of these jaws is so arranged that the axis at the back, on which the whole bar C swings laterally, is (approximately)

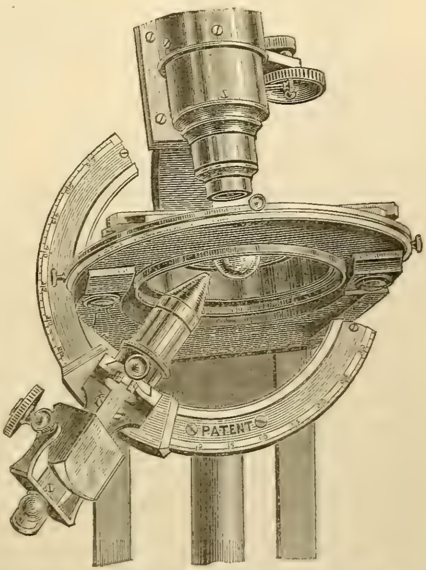
* Eng. Mech., xxxii. (1881) p. 582.

in the plane of the object supposed to be on the stage. The swinging bar C is provided with rackwork F on which the arm H, carrying the condenser E (which might be a 1-inch or 2-inch objective), can be moved up or down by the milled head D. The arm H is fitted to slide for convenience of centering with the optic axis; the mirror I is also made to slide for the same purpose. These sliding movements also permit the use of slightly excentrical pencils, which are found to give increased power of resolution in particular cases. The condenser E can be racked to focus the illumination on the object. The lateral swing of the bar C will then provide the whole range of oblique illumination in altitude concentric with the object, by suitable adjustment of the mirror. The swinging bar also permits the condenser and mirror to be used *above* the stage for "opaque" illumination.

It is obvious that this apparatus admits of application to many of the less expensive forms of Microscope at a very moderate outlay, and that other modifications may be suggested that would add materially both to its efficiency and its cost. We understand that Messrs. Watson have applied a disk at C for registering the angle of obliquity. A centering arrangement with rectangular motions might be advantageously applied on H.

**Swift's Radial Traversing Substage Illuminator.**—Messrs. Swift have (very advisedly) abandoned the second sector at right angles to the first,* and now issue the instrument in the form shown in Fig. 189.

Fig. 189.




We extract (slightly altered) the following remarks which they make as to the relative value of condensers and swinging substages:—

"This arrangement (Fig. 189) is superior to the ordinary swinging substage, as it does not in any way impair the steadiness of the upper stage, being slid into a dovetailed fitting on the limb of the Microscope, in lieu of the substage which is detached. Beyond this it has the advantage of being light and handy, and the condenser, if necessary, can be brought above the stage for the illumination of opaque objects. We would only, however, recommend this apparatus to those who wish to avoid the trouble of using an achromatic condenser, although this latter piece of apparatus when in

* See this Journal, iii. (1880) p. 867.

skilful hands is by far the best arrangement of the two, the former ingenious contrivance being suitable for one class of illumination only. . . . We do not hesitate to recommend the achromatic condenser as being superior to any other method of substage illumination, for in spite of all that has been both written and said in praise of the swinging substage illumination, the practical results hitherto obtained by it prove that its resolving capabilities have been greatly exaggerated, when compared with the performance of a high angle achromatic condenser."

**Kelner Eye-piece and Equilateral Prism as a Means of Illumination.**—Mr. James Smith points out that whilst both the Kelner eye-piece and the equilateral prism have long been in use for illumination, the combinations he employs have, he thinks, some novelty, and he thus describes them :—

Fig. 190.

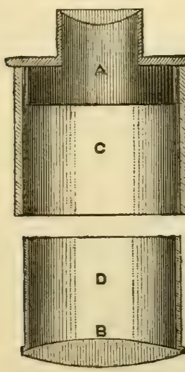
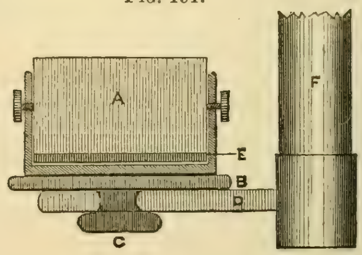



Fig. 191.




"It will be seen from Fig. 190 that I have divided the Kelner eye-piece into two parts, the eye-lens A being in an outer tube C and the field-lens B in another tube D sliding into the former. When the field-lens is upwards and pushed up into the tube C the eye-piece will be in its normal state, and act as an illuminator for high powers (up to the $\frac{1}{50}$), as described and used by Dr. Beale; but when the field-lens is reversed as in the drawing, the two lenses are then considerably separated, a much larger but more softened spot of light is the result, and it can be used advantageously with low powers even down to a 3-inch objective, giving a fully illuminated field.

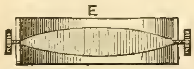
In combination with the eye-piece I use an equilateral prism A mounted as in Fig. 191, turning on its axis and also at right angles to it by means of a circular plate B C. The prism has cemented to it a piece of pale-blue glass E, and the whole slides on the mirror-arm F in the usual way. The equilateral prism is convenient, as taking the light from any side indifferently. When the light from the lamp passes *through* the blue glass it is modified, and a fine white light is obtained more like daylight, and the natural colours of delicate objects such as diatoms and desmids in fresh water are beautifully shown;

the definition also of colourless objects is much improved. When, however, the prism is turned round and the light taken by *reflection* from the coloured glass, a delicate monochromatic light is obtained—very grateful to the eye—and many objects with low powers (1-inch and 2-inch) are brought out with a clearness and beauty that must be seen to be appreciated. Monochromatic light has been used with much success by many observers, and this prism is a very convenient mode of getting it.

With the eye-piece and prism in combination I can show *P. angulatum* and *quadratum* with splendid effect, magnified 1100 to 1500 diameters, and then by simply refixing the eye-piece (as in Fig. 190), and with the monochromatic light, I can show whole insects of small size with a 3-inch objective, the same illuminators serving thus two very widely different ends.

It will be seen that I invert the fixed lens as in the drawing to save using an inconvenient length of tubing. I think, however, the same purpose might perhaps be better answered by mounting the field-lens in a very short piece of tube as in Fig. 192 E, furnished with two screw heads, and running it up and down by means of two parallel slits in the tube C. In the same way a small diaphragm might perhaps be used with advantage between the two lenses of the eye-piece. I have not obtained any advantage by the *gradual* approximation of the two lenses of the Kelner eye-piece; they act best for each purpose (high or low power illumination) either close together in their normal position or a good distance apart. This arrangement of the prism cannot be used by daylight without giving monochromatic light; however it might be remedied by not cementing the piece of blue glass to the prism. In that case for night-work either a piece of deeper tint would have to be substituted when the monochromatic light was required, or two pieces of the same pale tint must be used."

FIG. 192.




**Difference in the Appreciation of the apparent Size of Microscopical Images by different Observers.*** — M. C. Montigny has undertaken an investigation of this subject with the object more especially of determining whether the differences which are well-known to exist in different persons, depend entirely upon the inequalities in the distances of distinct vision, objects, as is well known, appearing to be larger to short-sighted than to long-sighted persons.

In the first series of experiments the observers were not accustomed to microscopical observations, being nine pupils of the upper class of the Brussels Athénée, and the objects were discoid globules of human blood, which were compared with twelve small circles of different sizes, 0·5 mm. to 7 mm., traced on a card, and elliptical globules of frog's blood, compared with ten ellipses, the long axes of which increased from 1 mm. to 10 mm. The cards were placed at very nearly the distance of distinct vision of the particular observer, previously carefully ascertained. The same globule was always

* Bull. Acad. R. Sci. Belg., xlix. (1880) pp. 670-8.

observed, and care was taken that the eye of the observer was in all cases close to the eye-piece, so that the apparent size of the image should not be affected by any variation in the distance of the eye from the eye-piece. The magnifying power of the Microscope (for the author's sight) was 312.

The following table gives the results obtained, the case of the shortest sight being taken as unity:—

| Observers. | Distance of Distinct Vision. | | Size of the image of Human Blood-corpuscles. | | Size of the image of Frog's Blood-corpuscles. | |
|---|---|---|---|---|---|---|
| | Absolute. | Relative. | Absolute. | Relative. | Absolute. | Relative. |
| | mm. | | mm. | | mm. | |
| A. | 160 | 1·00 | 3·0 | 1·00 | 8·5 | 1·00 |
| B. | 208 | 1·30 | 2·8 | 0·93 | 7·5 | 0·88 |
| C. | 233 | 1·45 | 3·0 | 1·00 | 9·0 | 1·04 |
| D. | 233 | 1·45 | 3·5 | 1·17 | 9·0 | 1·04 |
| E. | 235 | 1·46 | 3·5 | 1·17 | 9·0 | 1·04 |
| F. | 270 | 1·70 | 3·0 | 1·00 | 8·0 | 0·94 |
| G. | 310 | 1·94 | 3·5 | 1·17 | 9·0 | 1·04 |
| H. | 320 | 2·00 | 3·5 | 1·17 | 8·0 | 0·94 |
| I. | 340 | 2·12 | 4·0 | 1·33 | 9·0 | 1·12 |
| Average | 256 | 1·60 | 3·31 | 1·10 | 8·61 | 1·00 |

It will be seen that the apparent size of the images did not vary in regular accordance with the variation in the distance of distinct vision.

In the second series of experiments observers were selected who were well accustomed to scientific observations; M. Piré, Professor of Natural Science, and MM. Niesten and Fievez, of the Royal Observatory.

The following table gives the results, arranged according to the length of vision of the observers:—

| Observers. | Distance of Distinct Vision. | | Size of the image of Human Blood-corpuscles. | | Size of the image of Frog's Blood-corpuscles. | |
|---|---|---|---|---|---|---|
| | Absolute. | Relative. | Absolute. | Relative. | Absolute. | Relative. |
| | mm. | | mm. | | mm. | |
| Montigny | 195 | 1·00 | 2·0 | 1·00 | 6·0 | 1·00 |
| Fievez .. | 240 | 1·23 | 2·3 | 1·15 | 7·5 | 1·28 |
| Niesten .. | 280 | 1·43 | 2·7 | 1·35 | 8·0 | 1·34 |
| Piré .. | 350 | 1·79 | 4·0 | 2·00 | 14·0 | 2·43 |
| Average | 266 | 1·36 | 2·75 | 1·37 | 8·87 | 1·51 |

Here the apparent sizes of the images follow exactly the order of the lengths of distinct vision, and M. Montigny concludes therefore that the variations that are found to exist in the case of experienced observers depend primarily upon the inequalities in the observer's vision.

There are however other influences, as may be seen by the case of M. Piré, whose estimations were too great in the two cases, relatively to those of the other three observers. Moreover in his case the

relative size of the two kinds of globules varied from 2·00 to 2·43, while with the other observers they were approximately the same, the forms and different dimensions of the two corpuscles being without practical influence. If we take the mean of the relative sizes of the images of the two kinds of corpuscles for each observer, and divide by each of the means, and so find the length of distinct vision, the quotient ought to be approximately equal to unity for all four observers, if the apparent size of the images were exactly proportional to the distances of distinct vision. The following comparison shows however that it is not so :—

| | M. | F. | N. | P. |
|---|---|---|---|---|
| Relative vision .. .. .. | 1·00 | 1·23 | 1·43 | 1·79 |
| Mean of the relative sizes of the images .. .. .. .. | 1·00 | 1·20 | 1·34 | 2·22 |
| | 1·00 | 1·025 | 1·067 | 0·806 |

Whilst, therefore, the apparent size of a microscopical image is principally affected by the length of distinct vision, yet there is an additional influence, similar to the personal equation (*erreur personnelle*) of astronomers, which produces more or less modification.

**Conditions of Aplanatism for Wide-angled Pencils.**—It is a very common supposition that the necessity for constructing microscopical objectives of several lenses, instead of one only, is entirely a question of correcting spherical and chromatic aberrations,—that the practical method for correcting spherical aberration with a wide-angled pencil in fact consists in the *distribution* of the refraction over several lenses.

The dioptrical researches of Professor Abbe—from which the law of aplanatic convergence * was one particular result—show that the *successive* refraction of the rays by *several* lenses one above the other is the essential condition on which depends the *formation of an image by wide-angled pencils*, quite independently of the question of spherical and chromatic correction.

If an objective of say 140° angular aperture were constructed which should collect the rays in a similar mode to that of a single lens (where the semi-diameter of the emergent pencil $\rho = f \tan u$ and not $f \sin u$), and this objective was *perfectly corrected for spherical aberration*, a *plane* object would nevertheless be delineated like Fig. 193—a conical surface with a point, instead of a plane or moderately curved field.

Fig. 193.

A single lens can never fulfil the condition of aplanatism—that is of correct formation of the image—except for small angles for which the tangent and sine are nearly identical.†

**Penetrating Power of Objectives.**—We have added to the Numerical Aperture Table on the wrapper of the Journal a further

* See this Journal, *ante*, p. 322.
† See further on this subject, this Journal, iii. (1880) p. 509.

column (calculated by Mr. Stephenson) showing the "penetrating power" of objectives from a numerical aperture of ·50 to 1·52.

"Penetrating power" or "focal depth" is in inverse ratio to the numerical aperture. Thus, if a dry objective of 180° angle, or 1·00 N. A., is taken as unity, the penetrating power of one of ·50 N. A. would be 2, and of an oil-immersion of 1·50 N. A., ·667.

This follows from the consideration that the depth of focus ($\phi$) is —other circumstances being equal—inversely proportional to the linear diameter of the delineating pencils at their emergence from the eye-piece. This diameter is $= 2 f a$, $f$ being the focal length of the whole Microscope,* and $a$ the numerical aperture, and the depth of focus is therefore inversely as $a$, provided the whole aperture of the system is utilized by the image-forming pencils.

It must be carefully borne in mind, however, that this column of "penetrating power" is by no means on a level, in practical value, with those indicating the "illuminating power" and "resolving power."

As was shown by Prof. Abbe in the paper translated at p. 680, the total *depth of vision* of the Microscope depends upon two factors: (1) the power of *accommodation* of the eye, and (2) the *depth of focus* of the objective.

The depth of focus again consists of several elements, the medium in which the object is, the magnifying power of the Microscope, &c. The *penetrating power* of the objective $\left(\frac{1}{a}\right)$ is *one* only of those elements, so that with exactly the same values of $a$ (i. e. with the same numerical aperture) the depth of focus might considerably vary, if in the one case the object were in air and in the other in balsam, or if the amplification was different in the two cases.

By referring to the equation at p. 689,

$$\textit{Depth of vision} = n \frac{L^2}{N^2} \lambda + n \frac{L}{N} \frac{\omega}{a},$$

it will be better seen how many *other* elements make up the total effect of depth of vision, in addition to $\frac{1}{a}$, viz.:—

$n$ = the refractive index of the medium in which the object is.
L = the distance of the virtual image from the "eye-point" above the eye-piece.
N = the linear amplification of the virtual image.
$\lambda$ = the range of accommodation of the observer's eye in ordinary vision.
$\omega$ = the angle under which the circles of indistinctness may appear in the virtual image.

* The focal length of the *whole Microscope* is the focal length of that infinitely thin lens, which would give the same amplification of an object if projected to the same distance. If the amplification of the whole Microscope is = N, the virtual image being projected at a distance of vision = L, we have $\frac{L}{N}$ = equivalent focal length of the Microscope.

**Penetration.**—We gave at pp. 322–3 of vol. ii. and pp. 886–7 of vol. iii. an account of the discussion which was started in America on this subject, the view on one side being that penetrating power does not depend upon the aperture, but is only residual spherical aberration—that "the amount of penetration increases with the amount of the spherical aberration in the objective which has been left uncorrected, and decreases in proportion as the corrections for spherical aberration approach perfection."

The notion that penetration arises from the defective construction of an objective by the optician is, we need hardly say, wholly untenable.

We have delayed reprinting the remainder of the discussion until after we could give the translation of Professor Abbe's paper on the subject (see pp. 680–9), which has placed the question of penetration on the scientific basis which it has so long needed. The view that it is impossible for an objective to possess at the same time penetrating power and perfect definition is seen to be equally untenable, the defining power of an objective not being connected with its penetrating power, both low- and high-power, narrow-angled and wide-angled objectives, if properly made, all being capable of possessing the most perfect defining power.

The following is a summary of the remainder of the discussion to which we have referred, and is in reply to that printed at p. 866 of vol. iii. :—

Mr. C. M. Vorce* defines penetration in objectives as that quality by which the objective is able to present the images of different planes of an object in such close superposition, that the eye distinguishes them simultaneously, as the images of objects seen by the unaided eye are perceived; and he claims that the images presented to the eye by objectives having this quality of penetration impress the mind at the instant of view with a true idea of the bulk and substance of the object, and the arrangement and relation to each other of its parts. The reverse of this is true of the images presented by objectives, in which the above described quality has been sacrificed to the attainment of superior definition, and which he calls "defining objectives," as distinguished from the others called "penetrating objectives." Comparing the effect of these two qualities, the author argues that the mind is more likely to obtain a correct idea of the structure of an unknown object, if the images of it presented to the eye by an objective, resemble in character those received by the eye direct from natural objects, as is the case with penetrating objectives, than if the mind is compelled to successively compare with each other the images of separate parts and different planes, and laboriously trace out their relation to each other. He further contends that penetration is equally as necessary in high-power objectives as in low-power ones. The statement of the Rev. Mr. Dallinger, as to the $\frac{1}{35}$-inch objective made for him by Powell and Lealand, and which he used in his researches upon septic organisms, pub-

* Amer. Mon. Micr. Journ., i. (1880) pp. 170–1.

lished in August 1878, support, the author contends, the position taken by himself. Mr. Dallinger's description of the penetrating power and fine definition of the lens, is evidence that a superior objective for delicate original work, requires penetration as well as definition.

The practical conclusion is, that neither penetrating objectives nor defining objectives are alone sufficient for all classes of microscopical investigation; but both kinds are needed, of all the powers, and if the microscopist is limited in the number of his lenses, he will find the widest capabilities in the low-power defining, and high-power penetrating, objectives. The paper closes with the recommendation that opticians should endeavour to secure the best possible combination of defining power, with penetration, in the same objective.

Mr. Vorce further writes on the same subject:*—

"I partly agree with Dr. Blackham and his followers, but my views may be stated thus: Penetration is antagonistic to *perfect* definition, and, therefore, penetration is an objectionable quality in objectives whose purpose is definition solely. But mere definition is not the sole purpose of objectives, and in those objectives whose purpose is comprehensive view, penetration is a virtue as well as is flatness of field. Fortunately penetration cannot be got rid of by the opticians, except at the expense of the field of view; and Dr. Blackham's 1-inch objective still retains some of it, while it has gained much over the narrow angles in definition, and in this respect his objective approaches somewhat to the capabilities of that wonderful optical instrument, the human eye, which has *both* penetration and definition in a very great degree, in consequence of its inimitable 'compensating adjustment,' so well described by the Doctor. In some objectives this faculty of penetration is very striking. I remember distinctly with what surprise I saw, long ago, under a 1-inch of first-class English make, a stained specimen of *Utricularia.* At one view were seen the top layer of cells, the spiral vessel occupying the middle of the stem, and the bottom layer of cells; and all these with so much distinctness that, while the threads of the spiral vessel were in actual focus, the cells above and below were so nearly in focus that there was no dimness to their outline, and without changing the focus the size, shape, depth, and arrangement of the cells of the stem could be clearly seen, and the structure and central position of the spiral vessel perfectly seen. I am not ashamed to say that to this day I long to possess that objective, which, according to Dr. Blackham, is so faulty."

Mr. Vorce also takes exception to the figures of wire netting which we referred to at p. 887, contending that they are fallacious as shown on paper. As given, the figures "show exactly what a non-penetrating objective would show, viz.: all the lines equally defined; but with a penetrating objective one set of lines would be a little clearer than the other, and although there would be a *slightly* poorer definition of the lines in focus, there would be sufficient definition of both

* Amer. Journ. Micr., v. (1880) pp. 183–4.

sets, and no difficulty in seeing what was the relative position of the two layers. Having first ascertained the relation of structure, *then* comes the opportunity for the perfect, non-penetrating, surface-defining objective to get in its best work."

**Advantage of the Binocular.***—Professor Abbe remarks :—

"The scientific value of stereoscopic observation will always remain a matter of individual opinion. The skilled microscopist who has become accustomed by years of practice to the solid interpretation of superficial images, forms an idea with complete certainty at one glance, or at most after a few turns of the adjusting screw, of the *solid* structure of even very complicated objects. Such an observer will only exceptionally desire any direct advantage from stereoscopic observation, as, for instance, when viewing objects of unusual composition; and what has been said above (see *ante*, p. 687) shows that no stereoscopic apparatus will ever make superfluous the acquisition of the art of indirectly recognizing solid forms.

"On the other hand, there is an advantage to be gained from *binocular* vision, as such, which is quite independent of its *stereoscopic* effect, and is in fact of importance precisely to those observers who have least to expect from the latter. I have been told by many competent microscopists in England that they use their binoculars whenever it is practicable, but not for the stereoscopic effect, but rather in order to employ both eyes, and avoid the evil effects which the continual strain upon one eye in course of time occasions. I have also found from my own experience that it would be well if regard were paid to this. It can scarcely be doubted that continuous one-sided vision by those who use the Microscope incessantly must gradually diminish the ability to use the eyes for ordinary vision—for example, in preparing objects and other work. From this point of view a binocular arrangement may be of value to those for whom stereoscopic observation is of subordinate interest."

### β. Collecting, Mounting and Examining Objects, &c.

**Apparatus for Pond-life.**†—Mr. R. T. Andrews describes an apparatus for obtaining Entomostraca, &c., to obviate the cumbrousness of the strained hand-net, off which it is difficult to get the animals into a bottle readily. It does not require that one should put the net over the bottle, and dash the water up, and so draw off the animals, nor is a separate vessel required in which to immerse the net.

It consists of a tin tube $1\frac{3}{4}$ inches diameter, and $2\frac{1}{2}$ inches long, with its front end turned over for strength and tinned; the other end tapered in $\frac{5}{8}$ inch long to the size of the cork of the bottle, 2 oz. or 3 oz., employed, and a short length of about $\frac{1}{2}$ inch of tin tube soldered thereon to fit the cork, thus making the whole apparatus about $3\frac{1}{2}$ inches long. In the inside, rather more than half-way down the large tube, a ring of strong wire is soldered and tinned; a brass gas nipple is inserted from the outside, and a ring of tin $\frac{3}{8}$ inch in width is made to fit rather

* Zeitschr. f. Mikr., ii. (1880) p. 20. † 'Science-Gossip,' No. 199, p. 164.

tightly. On the mouth of the tube is placed a small piece of fine net, and with the ring pressed into the tube equally all round, and all projecting parts of the net above the ring cut off.

Having inserted the net, the apparatus, with both ends open, is waved through the water, which entering by the larger end escapes by the smaller, leaving the crustacea on the surface of the net. The cork of the bottle is then inserted in the smaller end, and some water taken up from the pond, which will then by its reverse action wash off the animals into the bottle. The use of the cork of the bottle obviates the necessity of a spare cork, which is apt to get lost. Care should be taken not to fish too quickly, or comparatively little may be got, as the large quantity of water cannot get through the net; and also to fill the apparatus with water slowly and not up to the brim, or what has been caught is washed out.

Hanaman's Collecting-bottle.*—This consists, as shown in Fig. 194, of an ordinary wide-mouth bottle or fruit-jar, having a number of holes half an inch or more in diameter bored through the side at a distance from the bottom corresponding to the capacity of the bottles in which the collector intends to bring home his material. Over the holes and around the bottle is tightly tied, or laced, a piece of fine muslin, which should be at least three times as wide as the holes in the bottle. Over the muslin, both above and below the holes, a rubber is placed so as to make all water-tight, except at the points corresponding to the holes.

Fig. 194.

Any quantity of water may be poured into the bottle, and it will rapidly run out through the muslin covering the holes, leaving the organisms which it contained in the bottle, together with only so much water as the lower part of the bottle, below the holes, will hold. This can then be poured into smaller bottles for transportation, by so inclining the collecting-bottle as to allow its contents to run out on the unperforated side. More straining surface can thus be gained, and the nuisance of funnels (necessary in the Wright's form) be dispensed with.

The principle upon which this bottle is constructed is subject to a variety of modifications. For instance, a slit of any width, from $\frac{1}{2}$ to 1 inch, may be filed in the side of a fruit-jar, and thus additional straining surface be gained; or a tin or zinc can may be used, having a broad slit in its side over which the muslin can be stretched.

If it be preferred to have the strainer inside the vessel, this can be easily arranged by using a vessel with a slit, and placing a diaphragm of thin iron (ferrotype plate) inside, somewhat wider and longer than the slit in the vessel, and having in its centre a slit of the same size as that in the vessel used. A piece of muslin can be drawn over the

* Amer. Mon. Micr. Journ., ii. (1881) pp. 121–2 (2 figs.).

diaphragm, covering its side next the interior of the vessel and passing over the edges, thence upwards, downwards, and laterally through the slit in the vessel and around the outside of the same, as in the former case, rubber bands being applied as before over the upper and under edges of the muslin. There is no particular advantage to be gained by this mode of construction, but it is suggested as a modification which may be deemed desirable by some.

It is necessary that the holes in the vessel be bored at some distance from the top of the bottle, in order to get sufficient weight of water to force itself rapidly through the strainer. If the holes are made near the top of the vessel, it will not work much more rapidly than the Wright's form, although even in that case the absence of funnels is a great convenience.

Cleaning Diatoms.*—Mr. K. M. Cunningham gives some additional hints as to the application of bisulphate of potassa in cleaning diatoms which is applicable to the treatment of nearly all varieties of diatomaceous material:—

"Proceed as follows.

Crush to powder a few crystals of the bisulphate of potassa, and add to it a proportionate quantity of the material to be cleaned, mix intimately together, and transfer it to a hollow space practised in the end of a sound piece of charcoal. Then with the blowpipe direct the flame of a candle upon the mixture, when a violent boiling up will ensue, and when it finally ceases to fuse readily, when the potash appears opaque and of a whitish colour, it is to be removed and dropped into a thimbleful of water, and boiled a few seconds; the potash dissolves readily, and liberates the sand and diatoms in a cleaned state. After settling in a shallow porcelain saucer, draw off all the water and collect the diatoms into the smallest compass possible, and transfer them to a nickel; take the nickel in the wire tongs, and dry with blowpipe flame; it will dry immediately, and the diatom powder is to be scraped off and put aside for use.

All the requisites for the above process consist of a common dime blowpipe, small wire tongs, 6 inches long, to hold the thimble, nickel, &c., a pocket coin, a brass thimble, a few pieces of sound charcoal, a candle, and a small supply of the bisulphate of potassa.

When the bisulphate cannot be readily procured, an admirable substitute may be found in the following, viz. common powdered sulphate of potash, and a small quantity of sulphuric acid, both of which are always found in prescription drug-stores. In using these materials, the diatoms to be cleaned are mixed with an equal quantity of the powdered sulphate of potassa, and a few drops of sulphuric acid are mixed with it; it solidifies at once, and can be broken into suitable pieces to be fused on the charcoal, as before described. The superior advantages of the process here described will become apparent to those who have tried the acid methods of cleaning."

In a subsequent note † the same author says:—

"The following process is the result of a recent fortuitous

* Amer. Mon. Micr. Journ., ii. (1881) p. 93. † Ibid., p. 114.

experiment. Let us suppose that we have succeeded in bringing a quantity of diatomaceous material to the state of a beautiful white powder, as previously described, by the use of the bisulphate of potassa, or the more easily procured substitute suggested. We then proceed as follows: Procure a piece of silk about four inches square, of good quality, and of very close texture; moisten it thoroughly at first, and in its depressed centre place a small portion of the fused material to be cleaned; then add to it several drops of water to bring it in solution, collect the sides and corners of the silk together, twist them to prevent the escape of material or fluid, compress immediately above the material, and carry the pressure down gradually, without however bringing the pressure of the fingers to the bottom part of the silk; this compression forces out the water, and with the water a large percentage of the undesirable impurities contained in the material, while the close texture of the silk holds back the various diatoms and disks with the larger particles of sand. After the first compression a few more drops of water are added, and the pressure renewed as before. The silk is then turned inside out, and washed by gentle shaking in a deep watch-glass to remove the diatoms, &c. We now note an absence of milkiness in the product, and the cleaned residue remains at the bottom of the crystal; by transferring this to a deeper receptacle, we can then dip up the diatoms with a pipette to mount direct on slide or cover-glass. This method gives surprisingly fine results."

**Colouring Bacteria.***—In a recent paper on this subject C. Weigert (classifying Bacteria into Cocci and Bacilli, and the former again into Micrococci and Megacocci) points out that two methods are available for colouring these microganisms:—1stly, in clear fluids, and in dried thin layers; a method first employed by Obermeyer for preserving bacteria in the case of *Spirillum* and *Spirochæte Obermeyeri;* Koch being the first to colour preparations dried in this way; 2ndly, by sectional preparations hardened by absolute alcohol.

For most micrococci the nucleus colouring substance employed by zoologists may be used; as, for example, Schweiger-Seidel's modification of carmine, aniline, or hæmatoxylin. Micrococci are coloured red by all nucleus colouring kinds of carmine, as purpurin, fuchsin, and magdala: brown by Bismarck-brown and vesuvian; brownish violet by carmine, with subsequent washing of the preparation with alcohol to which some ferric sesquichlorate has been added; green by methyl-green: blue and violet by hæmatoxylin, iodine-violet, methyl-violet, dahlia, and gentian-violet. All aniline colouring matters are used by super-colouring the sections in strong aqueous solutions, and then removing the colour either in acetic acid or in alcohol, or in both, until the nucleus is differentiated.

For the larger Bacilli only the nucleus colouring aniline colouring matters can be employed; carmine and hæmatoxylin are useless

* Arch. f. pathol. Anat. (Virchow), lxxxviii. (1881) pp. 275-315. See Bot. Centrabl., vi. (1881) p. 423.

The basic aniline colours to be specially recommended are Bismarck-brown, methyl-violet, methyl-green, saffranin, fuchsin, and magdala, and gentian-violet most of all, employed as a 1 per cent. aqueous solution. In this the section is laid, and soon becomes diffused with blue, and is then placed for an hour or more in alcohol, and finally in water, alcohol, or oil of cloves. The most important condition is that the section be well hardened. In preparations coloured by gentian-violet the nucleus can then be coloured red by carmine, Partsch's alum-cochineal, Grenacher's alum-carmine, borax-carmine, or picrocarmine.

The following method is given for the manufacture of picro-carmine as a micro-chemical reagent:—2 gr. of carmine are immersed in 4 gr. of ordinary ammonia, and placed for 24 hours in a spot protected from evaporation, and then shaken up with 200 gr. concentrated solution of picric acid. After allowing to stand again for 24 hours, everything soluble is dissolved. Very small quantities of acetic acid are then added, until the first slight precipitate appears; and after the lapse again of 24 hours, a few drops of ammonia are added.

**Colouring of Suberized Membranes by Fuchsin.***—M. Olivier gives the following process for colouring suberized membranes:—the sections of the roots are treated with a solution of fuchsin, made with equal parts water and alcohol, by which the whole preparation is coloured. The sections are then steeped in absolute alcohol, which dissolves the fuchsin out of the membranes, which are composed of cellulose, whilst the suberized walls remain of a red colour.

**Nigrosine for Colouring Nuclei of Vegetable Cells.**†—M. Errera finds "nigrosine" an excellent reagent for the nuclei, which are coloured a very deep blue, and stand out very clearly, the rest of the cell remaining practically colourless.

Nigrosine is one of the derivatives of tar, and belongs to the class of indulines. It is soluble in water and insoluble in alcohol and ether, and for colouring should rank with safranine, methyl-green, and other recognized agents.

The preparation should be placed for a short time in a solution of nigrosine, and then washed in distilled water until the water takes up no more colouring matter. It can then be mounted in glycerine or in balsam or dammar. The former method is preferable if it is desired to study the protoplasm and the part of the nucleus formed by achromatine (of Flemming). The second should be adopted for the examination of chromatine (= nucleine), as the grains of starch which hinder observation are rendered invisible.

**Staining Nuclei.**‡—H. Grenacher uses for discovering the nuclei in organs which abound in pigment—viz. the eyes of spiders—a method which will probably be found useful in other cases, especially

* Bull. Soc. Bot. France, xxvii. (1880) pp. 234–5.

† Bull. Soc. Belg. Micr., vii. (1881) pp. cxxxiv.–v.

‡ Unters. u. d. Sehorgan d. Anthropoden, 1879, p. 24. Cf. Zool. Jahresber., i. (1880) p. 38.

when the treatment of the specimen with nitric acid is likely to render subsequent staining by the ordinary means difficult. The staining is effected by putting the colouring matters into the fluid itself, adding the slightest trace of nitric acid, and leaving the preparation to rest. Solution takes place, however, so slowly that it is from twelve to twenty-four hours before the clear space round the section appears. The pigment acts in this case like a staining material introduced from without; it disappears from those points where it previously existed, and is precipitated in the nuclei, the other parts of the tissue receiving only an insignificant amount.

**Seiler's Imbedding Substance.***—Dr. C. Seiler says that after many experiments he has found pure paraffin two parts and rendered mutton tallow one part, to be more satisfactory than any other imbedding material in the majority of cases, because if poured into the well of the microtome at a temperature of about 120° it will not shrink away when cooling, either from the tissue or from the wall of the well.

**Strasser's Method of Imbedding.**†—H. Strasser adds from 3 to 4 parts of tallow to the imbedding mixture recommended by Kleinenberg (spermaceti 4 parts, castor-oil 1 part). In order to be able to arrange very small objects in the required position and conveniently for cutting sections, he places them between plates of mica in the warm mass, whose temperature must not exceed 45° C. After cooling, the laminæ of mica may be readily detached, and the mass containing the object in the required position, and forming a thin plate, can then be fastened to a block of less easily melted material by means of heated pins.

**Loewe's Modification of the Ranvier Microtome.**‡—Dr. L. Loewe describes this as follows:—"The microtomes hitherto devised are based upon two distinct principles. One of these is that of Verick and Rivet, since variously modified by Brand, Leiser, Weigert, Long, and others, leaving the general principle, however, unaltered. By this instrument the preparation is raised on an inclined plane, as its height is reduced by being cut away, the cutting knife always remaining at the same level (see Fig. 195).

"When the object is of small dimensions this instrument gives results of great practical utility, and is certainly to be preferred to free-hand cutting. But it is different when objects of large dimensions and complex character have to be cut, such as the head of a full-grown rabbit with skin and hair in a continuous series of frontal sections, and it cannot be employed in any of those cases where application of great force is required for dividing very hard parts, teeth, bones, &c. This defect is inherent in the principle of the apparatus, and cannot be obviated by any modification, however

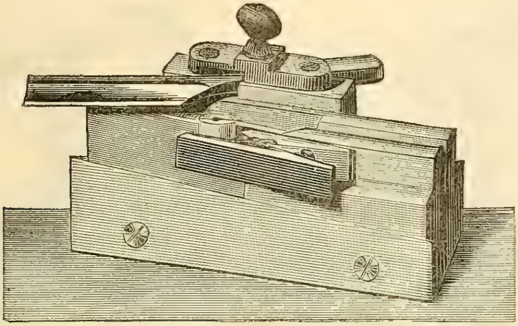
* 'Compendium of Microscopical Technology,' 1881, pp. 47–8.

† Morphol. Jahrb., v. (1879) p. 243. Cf. Zool. Jahresber., i. (1880) p. 35.

‡ 'Beiträge zur Anatomie und zur Entwicklungsgeschichte des Nervensystems der Säugethiere und des Menschen.' Cf. Zeitschr. f. Mikr. ii. (1880) pp. 123–39 (5 figs.).

ingenious, as will be evident from the following considerations. If we watch any one making fine sections of a complicated object with the free hand we see that at first the hand is held with the back inclined downwards, and in a position somewhat similar to that

FIG. 195.



assumed on going to shake hands. From this the hand is gradually changed during the cutting into a position inclined almost completely upwards, and at the same time, if the operator is not left-handed, the end of the knife describes an arc of 90° in the direction of a watch hand, the part of the knife which is furthest from the hand having the greatest rotation, whilst that where the knife is fastened to the handle remains almost stationary. This movement cannot, for mechanical reasons, be imitated in this microtome unless the guide of the knife and of the preparation (on the inclined plane) is changed from a straight line into one curved to the right, and at the same time a combined circular movement is given to the block which serves for fixing the knife, in which case a sickle-shaped knife fixed to the shaft at an obtuse angle must be used.

'The second or *Ranvier* principle appears to be more practical and capable of satisfying every requirement. Its origin is due to Ranvier, but it has since been considerably improved by Welker, Beetz, Gasser, Gudden, Schiefferdecker, and others. It is to this form that the author's modifications have been applied.

" As modified, it has the form represented in Fig. 196, and consists of two separable parts—(1) the microtome-cylinder proper, with its micrometer-screw for raising the preparation, and (2) a clamp which fastens the cylinder to the table (Fig. 197). The latter has a divided ring (seen in the upper left corner of the figure), which by a screw can be firmly attached to the neck of the cylinder. It is essential that the cylinder and the clamp should be capable of being detached, both for enabling the instrument to be cleaned, and also for altering the position with respect to the table of the object imbedded in the cylinder.

" The modification consists, therefore, in this: Instead of the microtome being held in the hand (Ranvier), or fixed in a water reser-

voir (Gudden), or standing free on the table (Schiefferdecker), it is attached to the table, and by this means both hands are set free. Compared with Gudden's microtome, there is a gain in the increased convenience and the reduced loss of light; while there is in-

Fig. 196.

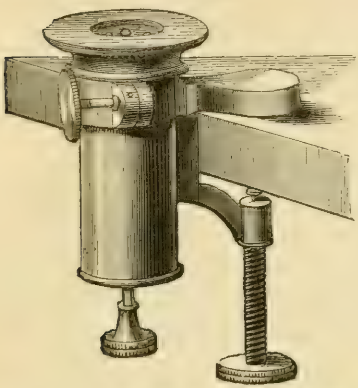
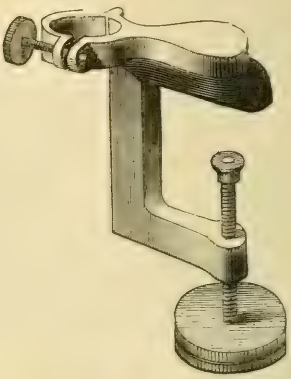


Fig. 197.



creased stability and firmness, compared with Schiefferdecker's method of simply placing the instrument on the table.

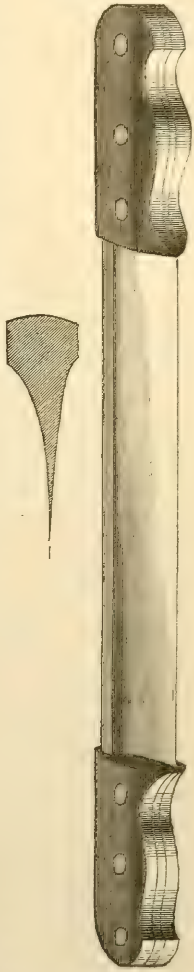
"It may be objected that cutting under water is impracticable with this instrument. To this it may be replied that section cutting under water is only intended to obviate the brittleness of the preparation; the same object is attained by glycerine jelly in a far more practical manner. This imparts to the whole a uniform consistency for cutting purposes, and binds it together into one firm mass without a trace of brittleness. Cutting under water can therefore be dispensed with.

"Katsch, of Munich, has made an arrangement for the larger instruments, by which a large wheel with four projecting teeth—placed horizontally and soldered to the lower head of the micrometer screw—allows the bottom of the cylinder to be raised or depressed more quickly. Rainer, of Vienna, has made the whole bottom of the cylinder, together with the micrometer screw, to fit in with a kind of bayonet fixing, so that a rapid change of the object (imbedded in oil and wax) is practicable. The fixing of the wax and oil cylinder enclosing the object is effected in the older instruments on Gudden's plan by means of three small buttons, the section of which is mushroom-shaped, which project from the movable base-plate of the microtome. Latterly Thamm, of Berlin, has substituted for these buttons a long groove, 1 cm. broad and 1 mm. deep, which runs across the middle of the base-plate of the cylinder; by this means facility in taking out the oil and wax cylinder is attained."

**Knife for Large Sections.**—Dr. Loewe also explains that for large sections through the bodies of mature animals a very long, heavy, and broad knife should be used, as in Fig. 198, which also gives a transverse section showing the peculiar grinding away of the blade to

form a biconcave surface. Its total length is 64 cm. or deducting the two handles 44 cm., and its breadth 4·5 cm. The thickness of the back is 1·5 cm., and its weight 2062 grammes. The two solid fixed handles of lead are each 1 decim. long, and can be conveniently grasped with the whole hand. Lead is employed to increase the weight of the instrument.

FIG. 198.



The force with which the edge of the knife is applied to the object is obviously equal to the product of the weight of the knife and the velocity of its motion. It takes a very short time to learn how to manipulate a heavy knife with as much ease as a light one, and, in general, the heavier the knife the easier it is to cut with. For this reason, microtomes which are adapted for heavy knives are far preferable to those which, like the Rivet and its modifications, can only be worked with thin knives.

It has been urged against the principle of heavy knives that many animal objects are much too delicate for them, that by such large cutting instruments friable preparations can indeed be crushed, but not cut. This is not so. It is simply necessary to harden the preparation properly (which can be effected perfectly by the method described in the preceding note), and any object, however delicate or brittle, will not be affected by the weight of the knife. There can certainly be nothing more difficult to cut than the ova of *Rana* or *Bufo*, and yet, when these are properly hardened and well permeated with Klebs' substance, they can be beautifully cut with the largest knife. Sections of embryos of rabbits, 3 mm. long, are also cut, notwithstanding such objects are most delicate.

**Making Sections very quickly.***—H. de Lacaze-Duthiers recommends, for obtaining sections very quickly for preliminary investigation, that the object should be put into a strong, dark yellow, very hot solution of chromic acid. In a few minutes it will be so far hardened that the spot which is to be cut can be isolated; the latter (e. g. a small ganglion, &c.) is then transferred to a weak light yellow chromic acid solution of the ordinary temperature, and there left until any other preparations which may have to be made from the animal are completed.

As imbedding material, glue is used, which must be of the best quality, i. e. quite transparent; it is used as prepared in two different

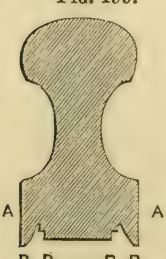
* Arch. Zool. expér. et gén, vi. p. xxxviii. See Zool. Jahresber., i. (1880) p. 35.

ways, as thin sheets and as a solution of the consistence of syrup; both must be kept in a damp atmosphere (under a glass shade, in case the air by the sea does not contain enough moisture); the sheets then remain soft, and have the proper consistence for cutting. The piece to be imbedded is now fastened to a sheet, near to its edge, by a drop of the liquid; a piece of tissue-paper or gelatin paper is saturated and softened with the solution and laid upon it, and on this notes as to direction of cutting, &c., can be written; other objects are laid on the same sheet parallel to the first. Finally, the whole is covered with a second and thinner sheet of glue, which quickly unites with the first. The mass thus formed remains so transparent that the prepared objects and notes are easily seen. The part of the sheet which contains the objects is now again covered by the bell-glass; the exposed part dries rapidly and becomes harder. It is soon possible to cut sections; the direction of cutting may be easily controlled with the aid of a lens, owing to the transparency. The sections are placed in water, and the glue dissolving readily, they are then fit for examination. The only difficulty is to keep the glue soft enough; if it becomes too hard, it is impossible to make sections; slight moistening is of use in this case; if the pieces of tissue are squeezed up by the drying of the glue, it is remedied by the swelling which is caused by this moistening.

**Cutting Sections of Myxomycetes, &c.***—For the lower vegetable forms with naked protoplasm, osmic acid is recommended. The currents in the protoplasm of Myxomycetes are instantly suspended, and in a very short time the plasmodium is sufficiently hardened to enable sections to be cut.

**Dayton's Cell.**†—Fig. 199 represents a perpendicular sectional view through the centre of a metallic die or punch. The sides A A, however, should be bevelled to form a cutting edge at B B. By prolonging the sides and forming another cutting edge at D D, rings for transparent cells may be made, the raised edge forming an efficient protection to the cover-glass.

Fig. 199.




The process of making the cell is thus described by Dr. R. Dayton:—

Drop melted sealing-wax or shellac upon a slightly warmed and oiled surface of plate-glass, until material has accumulated sufficient to a little more than fill the die, press the die down quickly and forcibly, and as the surplus resin exudes revolve the die so as to cut through to the glass. The cell produced by this process will be polished more or less in proportion to the finish the die has received in its manufacture.

The advantages of this cell are, that it is easily and quickly made, and can be modified as to form at slight expense. It can be attached

* North. Microscopist, i. (1881) p. 201.
† Amer. Journ. Micr., vi. (1881) p. 117 (1 fig.).

to the slide and the covers to the cell, by means of heat alone, or by varnish. A thin or thick object can be mounted in the same cell by placing the cover either upon the shoulder or upon the rim of the cell, and last, and not least, to those who have large exchange lists, is their inexpensiveness, as they can be made for less than two cents per dozen.

**Fluid for Mounting Infusoria, Algæ, &c.***—Dr. T. F. Allan uses the following solution for mounting Infusoria, Algæ, Characeæ, &c., which it is said preserves the arrangement of the cell-contents in a most excellent condition.

Wood-vinegar, sp. gr. 1·04, 100 parts.
Salicylic acid, 1 part.

Shake and allow to settle. This mixture is named "salicylic vinegar."

For Algæ, mix salicylic vinegar 1 part, glycerin 1 part, water 20 parts.

For Infusoria, mix salicylic vinegar 1 part, glycerin 10 parts, water 40 parts.

**Preservative Fluids for Botanical Preparations.**† — In 1872 MM. J. Groenland, M. Cornu, and G. Rivet published a little work ‡ on the preparation of Botanical objects for the Microscope, in which they gave a series of formulæ which they had found useful. This work being now rare, M. G. Huberson has reproduced these formulæ as follows:—

No. 1. *Equal volumes of glycerin (as pure as possible), alcohol, and camphor-water.* This fluid will preserve, either in bottles or cells, the greater number of vegetable tissues, and especially all cellular tissues of a certain solidity, such as horny albumen, epidermis, sections of leaves, and all woody, fibrous, and vascular tissues. Certain preparations it renders too transparent, especially those of very young organs; a fault that is corrected by the addition of water. (For tissues with cystoliths Nos. 3, 4, and 5 are preferable.)

No. 2. *Three volumes of glycerin to two of camphor-water* may be put to the same use as No. 1, but only in closed cells.

No. 3. 100 *grammes of distilled water to two of chloroform.* Shake up together for five minutes at least. About 1 gramme of the chloroform is dissolved, the remainder is precipitated at the bottom, and serves to keep the fluid saturated. It is used for all tissues in course of development and still tender, prothallia, embryonal sacs, archegonia and the fecundating organs of cryptogams in course of formation. (For the same parts completely developed Nos. 1 and 2 are preferable.)

No. 4. *The same as No.* 3, *with the addition of* 4 *or* 5 *grammes of*

* Amer. Mon. Micr. Journ. ii. (1881) p. 98.
† Brebissonia, iii. (1881) pp. 104–8.
‡ Des préparations microscopiques tirées du règne végétal et des différents procédés à employer pour en assurer la conservation. (8vo, Paris, 1872.) 76 pp. and figs.

*glacial acetic acid.* This preparation preserves Confervæ perfectly without contracting the chlorophyll, to which it merely gives a brownish tint. It presents one peculiar advantage in that it absorbs the air-bubbles which objects often contain after being placed in the cell. In this manner pith and fungi with numerous spores (Agarics, *Penicillium*) which often retain, do what one may, a large number of air-bubbles, can be prepared with success and without the necessity of taking numerous precautions. A few days after the cell has been closed, the air-bubbles, if not too numerous, will have disappeared. Consequently, whenever washing in alcohol is inconvenient, this fluid should be used.

The acetic acid destroys the calcareous concretions which sometimes exist on the surface and even the interior of Algæ. Bubbles of carbonic acid are in this case given off, and for some days spoil the appearance of the preparation, but they disappear before long. The proportion of acid is pretty strong, but experience shows that a slight excess of this acid is not injurious.

No. 5. *Camphor is dissolved in chloroform until it is saturated.* The superfluous camphor is as far as possible removed and fresh chloroform equal in amount to the first is added. Four grammes of this solution is dissolved in a litre of distilled water; no precipitate being produced.

This fluid may in most cases replace No. 1. It gives less transparency to the preparations, but it possesses the advantage of but slightly contracting the primordial utricle. For this reason it may be employed for preserving even the most delicate marine and fresh-water algæ, desmids, diatoms, with their endochrome, &c. For the very delicate algæ, such as the Confervæ (*Spirogyra*, *Rhynchonema*, &c.) preference is given to the following:—

No. 6. 75 *grammes of camphor-water*, 75 *of distilled water, and* 1 *of glacial acetic acid.* This formula was invented by Dr. Ripart and cannot be too strongly recommended.

No. 7 *is a gummy mixture* for fixing the objects in the cells before putting in the preservative fluid. Dissolve, cold, completely white gum arabic in twice its weight of camphor-water, adding to the solution, which is not perfect till the expiration of two or three days, three-quarters of its weight of glycerin. It should be kept several months in a long narrow bottle till the fluid has become completely limpid through the deposit of the corpuscles which it at first holds in suspension.

No. 8 *is a gelatinous mixture* intended to replace Canada balsam. Soak perfectly white gelatin in cold water for about twelve hours, drain it, and set the vessel which contains it in warm water. When it is melted mix an equal volume of glycerin with it. The mixture solidifies on cooling. When required for use it is liquefied by plunging the vessel containing it in warm water.

No. 9. 500 *grammes of distilled water and* 1 *of phenate of soda.* This fluid will preserve (in cells only) a host of vegetable tissues and microscopical plants. The previous formulæ are in general preferable, but in cases where they do not answer this fluid may be tried,

especially for objects which are very delicate and very sensitive to the effects of endosmosis.

**Chloral Hydrate for Preserving Tissues.***—Dr. W. W. Munson, being often obliged to postpone the dissection or other preparation of insects, &c., finds that putting a little chloral hydrate into the water preserves all animal tissues perfectly, without hardening or otherwise changing them, for any length of time. Five grains to an ounce of water is strong enough for all small objects.

Vegetable specimens may be kept fresh in the same way. The solution must not be too strong, say only a grain or two to the ounce.

**Chalon's Microscopic Finger.**†—Under the title of "Arrangement des Diatomées pures," J. Chalon describes an apparatus for picking up diatoms out of a mixed gathering, which, as he rightly says, "in default of any other merit possesses at least that of simplicity."

To a thin piece of deal 15–20 cm. long a hog's bristle of 4–5 mm. is articulated by means of a spherule of lead (a large shot) held between two brass rings. It forms, therefore, a lever with unequal arms, the wood one part and the bristle the other. The spherule is the fulcrum.

Any movement given to the extremity of the long arm of the lever becomes very slight and also reversed at the end of the bristle, so that in working with a power of 50 to 60 diameters the bristle seems, under the objective, to have a direct motion and an ordinary speed. It might be easily supposed that a needle was being used with a simple lens.

The apparatus is fixed to the stage by a clamp. If it is attached to the fixed part of a mechanical stage, great facility would be given for bringing any desired object under the point of the bristle. With a little experience 30 to 40 diatoms can be arranged in an hour.

**Mounting Opaque Objects.**‡—Professor A. H. Chester, in a paper on this subject, says:—

"In mounting opaque objects the chief difficulties to be overcome are in fixing the object to the slide, and in preventing the cement from running into the cell after mounting. After many trials I have adopted the following method. The objects, if light, are attached by means of a thin solution of gelatin. A little spot of the solution is dried on the slip, and the objects are then placed upon it and attached by breathing on the slide. This is then allowed to remain on the hot plate until all moisture has been driven out. If a heavier object is to be mounted, a circle of Brunswick black is turned on the centre of the slip, which is then placed on the hot plate until so hard that the object will not sink into it. It is allowed to cool, the object placed in position and fixed by heating for a moment over the lamp. If just the

* Amer. Journ. Micr., vi. (1881) pp. 117–18.
† Bull. Soc. Belg. Micr., vii. (1881) pp. cxx.–i.
‡ Amer. Journ. Micr., vi. (1881) p. 125.

right amount of heat has been applied, the object will be firmly attached, but will not sink into the cement. The slide is then placed on the hot plate, where it remains until the japan is baked perfectly hard, so that no subsequent heating will soften it.

After the objects are fixed and sufficiently heated, they are allowed to cool, and the ring applied to make the cell. This ring is of tin-foil, made as previously described.* A ring of black cement is carefully applied to the cool slide, and the tin ring pressed into it. Care is taken that none of the cement comes into the cell. This cement is a quick-drying dead colour, used by coach painters, and I think will soon be put on the market in tubes for use in mounting. It is thick, and sets in a few minutes. If necessary, another tin ring is laid on top of the first, in the same cement, and the cell is in this way built up until the cover-glass will be close to the object but not touching it. The cover is then put on with the black cement, clipped and set away. In an hour the clip can come off and another coat of black may be applied. This must dry hard, which requires several hours, when another coat is put on and left to harden. The next day a coat of shellac cement is put on. This should not be too thick, and the mount should be examined carefully to see that no holes are left in the shellac. The next day the white zinc may go on to fill up the angles and make a smooth surface, and in two or three days the final finish may be applied. It will thus be seen that the slide is completely finished in four or five days from the time it is started, that there is no need of having a lot of cells made in advance, but that each one is made to suit the particular object it is to contain, and if proper care be taken the object will be firmly attached to the slide, and there will be no running in. Of course some experience is required to know just when the conditions are fulfilled to ensure complete success, but it may be attained in the use of the means I have just pointed out.

For fluid mounts in cells I use the tin rings, cementing them to the glass with shellac, which I generally thicken with Chinese vermilion. After the object and fluid are put in the cell, the cover is laid on, the excess of liquid pressed out carefully, and the whole dried with blotting paper. Some of the thickened shellac is then put around the edge of the cover and left to harden. In an hour the slide can go on the turn-table, and a ring of shellac may be applied. No clip should be used. The next day the slide may be carefully washed and dried, when it is ready for another shellac ring. After this is set the white zinc may be put on as usual. Of course the fluids used must not be those that dissolve shellac, but camphor water or glycerin may be used without fear."

**Preparing Cuticles of Plants.**†—Mr. F. Kitton gives the following process for preparing slides of the cuticles of *Deutzia*, *Onosma*, *Alyssum*, *Hippophaë*, *Equisetum*, scalariform and spiral vessels, &c. The apparatus required is only a small porcelain saucer holding about an ounce, a spirit-lamp, a large watch-glass, two or three mounted bristles (rabbit or cat's whisker), about $\frac{3}{4}$ inch beyond the

* See this Journal, *ante*, p. 702.

† Sci.-Gossip, 1881, p. 182.

handle, and a human hair mounted so as to form a small loop. Also a "lifter" made of a "thick" thin glass cover, about $\frac{3}{4}$ inch diameter (this is more convenient if three of its sides are squared), cemented to a piece of glass tube $\frac{1}{4}$ inch diameter, and $\frac{1}{8}$ inch bore, by filling about $\frac{1}{4}$ inch with broken shellac, to be carefully melted, and then placed on the square edge of the cover, which should be hot. Chemicals: nitric acid and chlorate of potash, and distilled water.

The *modus operandi* is as follows: select, say a medium-sized *Deutzia* leaf, cut out a square, or any other shape, but take care to leave none of the margin, half fill the saucer with equal parts of nitric acid and water, and to this add a small pinch of the chlorate of potash, and gently boil over the lamp; carefully watch the leaf, and when the upper and lower cuticles begin to separate remove them by means of the lifter into a watch-glass filled with distilled water; the two cuticles will sometimes separate of themselves, but much more frequently require a little manipulation with the bristle to separate them: this may be done by carefully inserting it between them. When separated, float the lower cuticle * on a thin cover, and with the hair loop gently scrape off any remains of fibre, &c. The upper cuticle may be cleaned whilst floating by scraping the under surface with the loop; when clean float on to a glass slip. It is usually very difficult to turn the cuticle over, and as it is always desirable to have the external surface uppermost, it is necessary to mount one on the cover and one on the slide. A more difficult but better plan is to leave one of the margins of the leaf intact, and when clean float both cuticles on to the slide; when dry place the cover or the slide in turpentine, and mount in Canada balsam. The siliceous cuticles of *Equisetum* stems, barley-straw, cane, rice-husks, may all be obtained by this process, but they will not bear drying; they must, therefore, be removed first to strong methylated spirit, and then ether, and lastly turpentine.

**Mounting Raphides.**†—Mr. S. A. Webb gives the following process for obtaining and mounting raphides:—

"The hanging plant known as 'Wandering Jew' (*Tradescantia*) contains myriads of these needles. Place a slide upon the turn-table, cut off the stem of the plant transversely (somewhat obliquely), and you will find the juice forming a half drop on the cut end. Set the table in motion without delay, and place the drop on the cut end upon the centre of the slide, slowly moving it outward as the table turns, so that it shall not twice pass over the same spot, until you have formed a scroll-like circle with the juice of about $\frac{1}{4}$ inch diameter. Let the slide remain fifteen or twenty minutes, place a drop of fresh balsam upon the centre, and place upon it a half-inch cover-glass. Let the cover sink down slowly until it is in contact with the balsam throughout. If not level, press it gently, so that the balsam shall fill out handsomely. Set it away, but do not heat it. It will require some time to harden, but if in haste to use it, as soon as the balsam

* By upper and lower cuticle is meant that which may be upwards or downwards in the saucer.

† Amer. Mon. Micr. Journ., ii. (1881) p. 71.

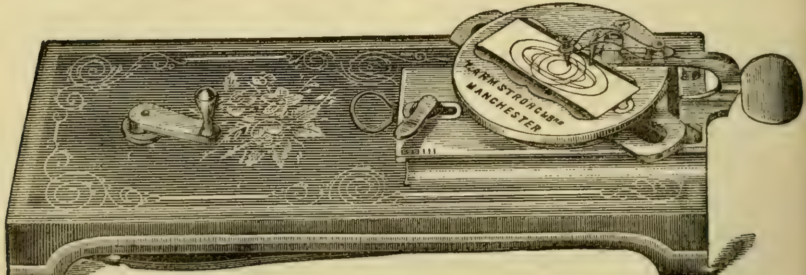
at the edge of the cover has hardened somewhat, run a circle of a solution of shellac in alcohol, so as to touch both the edge of the cover and the slide. This will hold all fast, even though the balsam be still liquid within. Finish this if you choose at once with tube paints, and your slide is done. Examine the slide by oblique (black-ground) light, or far better, if you have it, by polarized light. Use the green, not the purplish coloured 'Wandering Jew.' You will find the needles beautifully distributed, clean and looking like polished steel."

**Preparing Crystals of Metals.***—Professor A. H. Chester gives the following as his method of procuring crystals of the various metals:—

"The beautiful and rare crystals of gold of hexagonal form are prepared by first dissolving the gold in ten or twelve parts of mercury, and boiling for several hours. The mercury is then dissolved out by means of nitric acid, and the crystals of gold left of hexagonal shape, their beauty depending upon the perfection of the process. The silver, tin, copper, and other metallic crystals are best obtained by precipitation of the crystals by means of the battery. To obtain tin crystals the simplest method is to immerse the end of a bar of tin in a strong solution of the chloride. A thin layer of water is poured on the top. In a few days the crystals of tin will be found attached to the bar in the layer of water."

**Blue Glass for Test Objects.†**—E. Mauler mounts diatoms intended as difficult tests on or under blue glass. The object is twofold:—1st, to render the image clearer by monochromatizing the light entering the objective. In this case it is the cover-glass only which is blue, and it "has the effect of improving the often confused resolutions given by objectives whose chromatic aberration is badly corrected." 2nd, by using blue glass for the slide, or for the bottom of the cells, the light reaches the object monochromatised, a plan which replaces the more inconvenient one with sulphate of copper. Stronger illumination is of course necessary than with ordinary glass.

FIG. 200.




**Armstrong's Universal Turntable.**—This instrument (Fig. 200) is made by Messrs. T. Armstrong and Brother, of Manchester, and

* Amer. Journ. Micr., vi. (1881) p. 125.

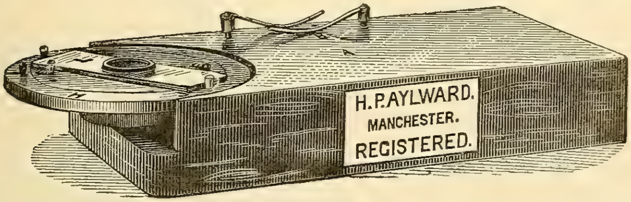
† Journ. de Microgr., v. (1881) pp. 111-12, and Bull. Soc. Belg. Micr., vii. (1881) pp. cxxxiii.-iv. and cxliii.

is claimed to be entirely different from any other form yet made.

It is constructed upon the principle of the "elliptical chuck," and so enables either circles or ovals to be traced with equal ease. It may also be used for cutting thin glass covers, either oval or circular, as well as for general mounting purposes.

**Aylward's "Concentric" Turn-table.**—This self-centering turn-table, designed by Mr. H. P. Aylward, of Manchester, is shown in Fig. 201. It is claimed to be accurately self-centering, and still

FIG. 201.




simple in its construction, so as not to be liable to get out of order, and at the same time easy and rapid in use. It essentially consists of two plates, the inner revolving on a pivot, whilst the outer one revolves concentrically on the inner, some pins being so arranged that by a simple turn of the outer ring they firmly grasp the slide and centre it, a simple reverse movement instantly liberating it. It will answer for slides of various widths, from 1 inch to $2\frac{1}{2}$ inches.

A is the ordinary wood block with steel pivot, on which the brass revolving table turns. B, two brass springs which fit in holes in the table, to be used when the slide is required to be out at centre (when not in use they fit in holes in the block, as shown in the figure). H, brass ring which revolves concentrically on the table, and having two conically headed pins J exactly $3\frac{3}{32}$ of an inch apart, to allow a $3 \times 1$ slide L to be placed lengthways between them. Two similar pins F are so placed on the table, that upon revolving the ring H they, in conjunction with the pins J, firmly grasp the opposite corners of the slide, and cause the centre to coincide with the centre of the table. I is a brass pin for more easily revolving the ring on the table, and thus securing and liberating the slide. Non-centering turn-tables can be converted into self-centering ones on this plan at small cost.

**Photographing Bacteria.***—K. L. Kaschka writes that the excellent photographs of Koch at first led him to believe that they could be made without great difficulty, but an unexpected difficulty was met with, so that it was impossible to find a colouring matter which would so act upon the sensitive plate as to make the bacteria print sufficiently black. Anilin colours, methyl-violet, fuchsin, and brown were first tried, but only the first two coloured the bacteria well, and although deeply coloured, as viewed by the eye-piece, they were scarcely

* Zeitschr. f. Mikr., ii. (1880) pp. 264-5. See also Amer. Mon. Micr. Journ., ii. (1881) pp. 53-4.

to be distinguished on the photographic plate, even when the latter was made very sensitive. Tincture of iodine and solutions of gold and silver salts were also tried, with negative results. Finally the cell-wall of the bacteria was subjected to a photo-chemical process in the following manner:—

After the drop containing the bacteria is dried upon the slide in the usual manner, the spot is moistened with an aqueous solution of a metallic iodide (cadmium iodide 1 : 50 was employed), and in two or three minutes the bacteria are sufficiently iodized. The slide is then carefully and rapidly washed with distilled water, and immediately flowed with a few drops of silver solution from the negative-bath. If the right time has been hit, and the iodide has not acted for too short a period, and the washing has not been continued too long, the contour of the dried drop will be seen to show a slight yellow colour, due to iodide of silver, which is formed. Only an exceptionally short exposure to light is sufficient, after which the developer (strongly acidified and dilute iron-developer) is added, and the drop suddenly becomes black. After thorough washing the deeply coloured bacteria are mounted in balsam, and they may then be readily photographed.

This method is only useful for photographic purposes, and there is some chance of mistaking fine silver precipitates for micrococcus or other forms. In case of any doubt of this kind, the original forms should be stained with anilin colours, and examined in the usual way.

Dr. G. M. Sternberg considers* this method of staining bacteria for photographing an improvement upon Koch's method of staining with anilin violet, for the violet gives very little photographic contrast, because it permits the actinic rays to pass. A method which he has employed with success, and believes to be new, is the following:—

The bacteria are dried upon a slide, or upon a thin glass cover, and are then treated with commercial sulphuric acid, a drop of which is placed upon them. After two or three minutes the acid is washed off by a gentle stream of water, and the bacteria are then covered with an aqueous solution of iodine (iodine grs. 3, potassic iodide grs. 5, water grs. 500). After a few minutes they will be found to present a deep orange or brown colour, which gives the desired contrast in a photograph negative.

This method is only useful for extemporaneous preparations which are to be photographed immediately. The colour fades after a time, and the bacteria undergo changes in form (swelling) as a result of this treatment, which renders the method unsatisfactory when the object is to make a permanent preparation. For this purpose nothing is better than the anilin violet, which indeed leaves nothing to be desired when a collection is being made without reference to photography. The specimens should be mounted either in solution of acetate of potash (Koch's method), or preferably in carbolic acid water.

Anilin violet ink, which may be obtained from any stationer, is a cheap and satisfactory staining fluid. One or two minutes' immersion

* Amer. Mon. Micr. Journ., ii. (1881) pp. 86–7.

in this is usually sufficient time to give the bacteria a deep violet colour. Those who have not resorted to this method will be astonished at the facility with which it is practised, and with the variety of forms which may be demonstrated at a moment's notice, without a resort to culture-experiments, or to a search in ditches or sewers. The mouth, the rectum, the extremity of the uretha in the male, and the vagina in the female, are constantly supplied with an incredible number of these minute vegetable organisms, and a great variety of forms may be observed, especially in the discharges from the bowels. The slightest possible smear of saliva scraped from the surface of the tongue, of vaginal mucus, or of fecal matter dried upon a slide, stained with violet ink and washed with a gentle stream of water, will furnish ample material for study, and will serve as a practical demonstration of the extensive distribution of the bacteria.

Bacteria may often escape observation, not only because of their minute size, but because they may have very nearly the same refractive index as the fluid which contains them. Assertions therefore, as to their not being found in certain secretions, &c., will have but little value, unless it is shown that this or some other efficient method of staining has been resorted to, and the objective employed is mentioned.

**Günther's Photographs of Pleurosigma angulatum.**—Dr. Carpenter has engraved portions of these photographs (× 2000 and central illumination) presented to the Society by Mr. O. Brandt,* and we subjoin the four figures which he gives.

Fig. 202 A shows normal hexagonal areolation, areolæ bright circles, surrounded by dark hexagons (the "beaded" aspect).

B. In upper part, areolæ and their dark borders graduating from circular to elliptical; in lower part, dark borders coalescing laterally, so as to give the appearance of continuous vertical lineation.

C. Areolæ larger, brighter, and more elliptical, their dark borders coalescing laterally, so as to form very decided vertical lineation.

D. Transition from hexagonal to triangular areolation, with three series of dark lines, one horizontal and two oblique.

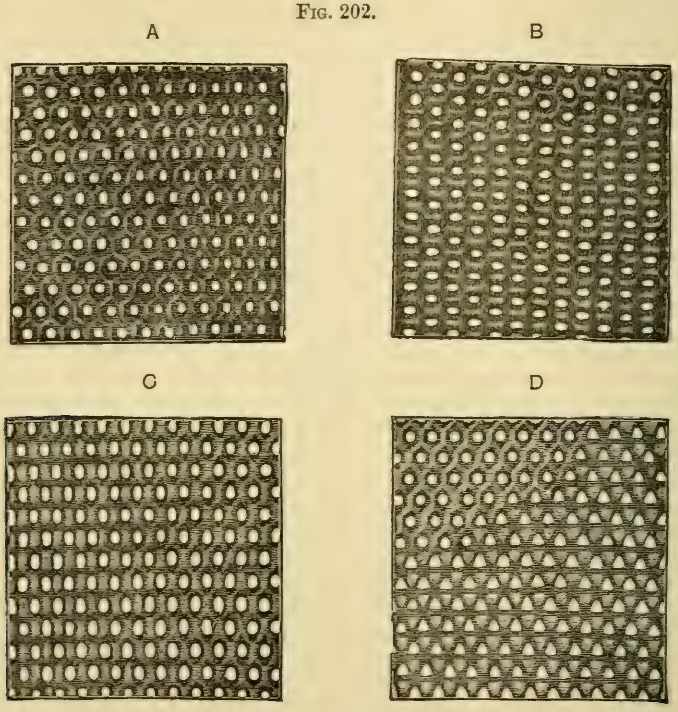
After discussing the nature of the markings of diatoms, it is added,† "Notwithstanding these considerations, however, it must be freely admitted that there is still considerable uncertainty respecting the real structure of the diatom valve. For it cannot be positively asserted that the focal adjustment which gives the image represented in Fig. 202 A, is more correct than that which gives the equally distinct images, B, C, and D, of other parts of the same valve, of which the last departs in the most marked manner from what is commonly regarded as the normal type. And now that it has been shown that these images are not formed dioptrically, but are resultants of the combination of numerous diffraction-spectra, it is impossible to entertain the

* See this Journal, iii. (1880) p. 1085.

† 'The Microscope,' &c., 6th ed. (1881), pp. 333–4.

same confidence as before that they truly *picture* the surface marking they are supposed to represent."

Fig. 202.




**Cohen and Grimm's Microphotographs of Minerals and Rocks.***—The first four parts of these photographs, illustrating the microscopical structure of minerals and rocks, have now been issued. Each part consists of eight plates, with four figures on each plate, which have been selected and arranged by E. Cohen.

The photographs are beautifully executed by J. Grimm.

**Braham's Lamp.**†—This is simply a diminutive lime-light with a plano-convex lens in front of it, and with a rack adjustment so as to produce from the small pea of light a divergent, convergent, or parallel beam. It is also fitted to a universal stand so that it can be placed in any desired position relatively to the object.

The lamp is fed by ordinary coal-gas, the oxygen united with it being pressed through a fine jet from a bladder, sufficient for an

* E. Cohen and J. Grimm, 'Sammlung von Mikrophotographien zur Veranschaulichung der Mikroskopischen Structur von Mineralien und Gesteinen.' (Stuttgart, 1881.)

† North. Microscopist, i. (1881) pp. 202–3.

hour's illumination being made at a cost of $1\frac{1}{2}$d. The light is said to be much purer than that from any oil lamp.

**Examining and Testing minute Particles of Blood.***—Dr. J. G. Richardson reproduces the method which he first published in 1875 † for this purpose.

"Procure a glass slide with a circular excavation in the middle, called by dealers a 'concave centre,' and moisten it around the edges of the cavity with a small drop of diluted glycerin. Thoroughly clean a thin glass cover about one-eighth of an inch larger than the excavation, lay it on white paper, and upon it place the tiniest visible fragment of a freshly dried blood-clot (this fragment will weigh from $\frac{1}{21000}$ to $\frac{1}{50000}$ of a grain). Then with a cataract-needle deposit on the centre of the cover, near your blood-spot, a drop of glycerin about the size of this period (.) and with a dry needle gently push the blood to the brink of your microscopic pond, so that it may be just moistened by the fluid. Finally, invert your slide upon the thin glass cover in such a manner that the glycerined edges of the cavity in the former may adhere to the margins of the latter, and, turning the slide face upwards, transfer it to the stage of the Microscope.

By this method it is obvious we obtain an extremely minute quantity of strong solution of hæmoglobin, whose point of greatest density (generally in the centre of the clot) is readily discovered under a one-fourth inch objective, and tested by the adjustment of the spectroscopic eye-piece. After a little practice it will be found quite possible to modify the bands by the addition of sulphuret of sodium solution, as advised by Preyer.

In cases of this kind, where the greatest possible economy or even parsimony of material is needful, I would advise the following mode of procedure for proving and corroborating your proof of the existence of blood, so that its presence in a stain may be affirmed with *absolute certainty*.

From a suspected blood-spot upon metal, wood, leather, paper, muslin or cloth, scrape with a fine sharp knife two or three or more minute particles of the reddish substance, causing them to fall near the middle of a large thin glass cover. Apply in close proximity to them a very small drop of three-fourths per cent. salt solution, bring the particles of supposed blood-clot to its edge and proceed as I have already directed.

After thus examining the spectrum of the substance, you may generally, by rotating the stage, cause the coloured fluid to partly drain away from the portion wherein, under favourable circumstances, should the specimen be blood, the granular white blood-globules become plainly visible, as do also cell-walls of the red disks. Among the latter, if your mental and physical vision is keen enough, you can by the aid of a $\frac{1}{25}$ immersion lens and an eye-piece micrometer

* Amer. Journ. Micr., vi. (1881) pp. 111–16, from 'Gaillard's Medical Journal.'

† Phila. Med. Times, 13th Nov., 1875, p. 78.

measure a series of corpuscles accurately enough to discriminate human blood from that of an ox, pig, horse, or sheep.

Lastly, to make assurance triply sure, lift up the thin glass cover, wipe off the tiny drop of blood-solution and clot you have been examining on the folded edge of a thin piece of moistened blotting-paper, let fall upon it a little fresh tincture of guaiacum and then a drop of ozonized ether, which will at once strike the dark-blue colour of the guaiacum test for blood.

In this way I have actually obtained these three kinds of evidence, to wit, that of spectrum analysis, that of the Microscope, and that of chemical reaction, from one single particle of blood, which, judged by a definite standard,* certainly weighed less than $\frac{1}{15000}$, and probably less than $\frac{1}{25000}$ of a grain."

**Microscopical Examination of Handwriting — Detection of Forgeries by the Microscope.**—We append the remarks † of Dr. R. H. Ward, of Troy, U.S.A. (President of the Buffalo Meeting of the American Society of Microscopists), on this subject, which we referred to at p. 946 of vol. ii.:—

"The examination of handwriting, with a view to determine its authorship, its genuineness, its age, and whether or not it has been altered from its original form and intent, is one of the most recent uses of the Microscope, and one, the importance, the reliability, and frequent applicability of which has but recently become known, and is even now not generally realized. Perhaps this is to be accounted for by the fact that large general experience, judgment, and tact in the use of the instrument, and skill in the manipulation, though necessary to this particular work, are not, in themselves, an adequate preparation for it. Much special study and special practice are required before anything useful can be done, or important should be attempted. But to a person really at home in the study of handwriting, both with and without the Microscope, this instrument furnishes a ready means for its accurate analysis. Those who are governed, not by respect for the rights of others, but only by the expectation of consequences that shall affect themselves, cannot learn too soon, or too well, the fact that writing can scarcely be changed after its original execution, so adroitly that the Microscope cannot detect the falsification.

The face of the paper, when once marred by disturbing the position of the fibres, can never be restored, and hence scratching and erasure can be recognized, though performed with consummate skill, and not distinguishable by other means. Inks which are alike to the unaided eye, are marked under the lenses by conspicuous differences of shades or colour, or density or purity, or chemical composition. Lines which look simple and honest may show themselves as retouched or altered by the same or by a different hand or pen or ink; and lines drawn upon new paper may look different from those drawn after it is old. The Microscope does not give any direct information as to the precise age of writing, but if used with sufficient caution it

* See 'Handbook of Medical Microscopy' (Philadelphia, 1871), p. 283.
† Proc. Amer. Soc. Microscopists, 1880, pp. 46–8.

can determine (not so easy or safe a task as might be supposed) the relative age of superposed, crossing, or touching lines; and it can generally state positively whether lines were written before or after related erasures, or scratchings, or foldings, or crumplings of the paper. In one important case my friend, Mr. Wm. E. Hagan, of Troy, who has given extensive and very successful attention to the study of writing, especially imitative writing, and in association with whom many of my own investigations in this field during the last dozen years have been carried on, established the date of the document by recognizing in the paper, fibres which had only recently been used in paper-making, and which, in connection with corroborative proofs to which they led, demonstrated that the paper was manufactured at a later date than that claimed by the writing upon it.

To discuss the subject of imitative writing would require the opportunities of a book, not of a fraction of a lecture; and many considerations of recognized importance connected with it are still under investigation and not sufficiently mature for publication. A few hints may be given in respect to those points which are well established and most generally applicable.

When a word, in a fictitious signature, for instance, has been constructed by tracing it with pencil lines over an original one, and subsequently inking it over with a pen, particles of plumbago can probably be somewhere detected and recognized by their position and their well-known colour and lustre. The mechanical effect of the point of a pencil upon and among the fibres of the paper can also be seen, notwithstanding the subsequent staining of the paper by the ink. This clumsy method of copying carries its own means of detection, and still it is not more easily recognized than are methods that are more subtle and seem more dangerous.

In writing copied or imitated originally in ink, either by tracing it over a copy or by drawing it freehand with a copy to inspect or to remember, the distribution of ink is peculiar and suggestive, indicating hesitation from uncertainty, or pauses to look at a copy, or to recall a style, or to decide as to a future course, just at points where a person writing automatically by his own method, and especially in writing his own name or a scarcely less familiar business formula, would pass over the paper most rapidly and promptly.

Again, there are certain ear-marks, results of habit, which finally become as natural as it is to breathe, and which characterize the writing of different individuals. Such are peculiar forms and styles of letters and of combinations of letters; methods of beginning or of ending lines, letters, words, or sentences; methods and places of shading or breaking lines, and of dotting, crossing, patching or correcting; habits of correcting or not correcting certain errors or omissions; the use of flourishes; and peculiar ways of connecting words or of dissociating syllables. In imitative writing these ear-marks of another ownership are generally copied with ostentatious prominence, if not with real exaggeration, in the capital letters and other prominent parts, but lost sight of in those less conspicuous places where imitation naturally becomes feeble and the habit of the writer unconsciously

asserts itself; and this revelation often becomes more positive by reason of the elaborate efforts that are made to suppress it.

Things are overdone from fear, which would have been negligently done from habit, not to speak of gross blunders proceeding from the same source. I once examined a disputed signature from which had been carefully scratched out a line, immaterial and inconspicuous, which conformed to the habit of another person interested in the case, but not to the habit of the ostensible author of the writing.

Furthermore, the genuineness of a writing may often be disproved by the very success with which it followed its copy, reproducing its mistakes, idiosyncrasies, or its adaptations to its own special surroundings, in which respects it may correspond too accurately with some one genuine signature (in the hands, for instance, of a suspected person), but differ unquestionably from the ordinary habit of the reputed author. Modifications of style by disease, as paralysis, may present similarly decisive discrepancies or coincidences. There is a peculiar tremor, too, about the writing of an individual, which is dependent on the physical conformation of the writer, as related to his habits of position, touch, and motion, which is quite characteristic, as it can be neither imitated nor concealed.

All these investigations in respect to writing can be best pursued with the aid of the Microscope, and some of them are entirely dependent upon it. For general view of the words a four or three inch objective is best adapted; for special study of the letters, a one-and-a-half inch; and for minute investigation of the nature of the lines or character of the ink, a two-thirds or four-tenths. The lenses, except the last, should be of the largest angles ordinarily made, and all should be of flat field and of the best possible definition. The microscope-stand should have a large flat stage, though it is generally preferable to use a small portable stand which can be moved freely over the paper and focussed upon it at any point without the use of a stage. For this purpose I sometimes use a tank Microscope, but more frequently a pocket Microscope, with its tube prolonged through the stage by adapters, so that it focusses directly upon the table. Even so large an instrument as Zentmayer's Histological may be so used to advantage, though a lighter form and smaller size is far more convenient and sufficiently steady for this work. A medium-sized bull's-eye is sufficient for the purpose of illumination, and good judgment is more important than, if not incompatible with, the employment of an ostentatious and unnecessarily elaborate apparatus."

Professor Lester Curtis also read a paper* before the State Microscopical Society of Illinois, in December 1879, on the "Microscopical Examination of Signatures," in which, amongst other matters, he deals with the process for determining which of two lines which cross each other was written first—the determination being easy where ink has been used, but impossible in the case of pencil, which leaves a film on the surface of the paper of an imperceptible thickness, so that no matter how many marks cross at any one place the surface is not raised.

* Amer. Mon. Micr. Journ., i. (1880) pp. 124–9.

At the meeting of the American Society of Microscopists, held at Detroit, in August, 1880, Mr. C. M. Vorce * read a paper on this subject in which he dealt with the five elements which he considers determine the character of a person's handwriting:—the paper, the pen, the ink, the personal qualifications of the writer, and the conditions under which the writing is done. Any one of these being changed from the ordinary conditions, the microscopical conditions of the writing are almost sure to be changed also.

So far as the *paper* is concerned, its glazed surface is the only characteristic which affects writing. The author illustrated by drawings the various widenings or "webs" which are always found at points where two lines cross, explaining how a variation of speed, a change in the kind of ink, and other causes affected this web. Upon rough paper the lines always have a ragged edge; the webbing is, if anything, less than upon hard, smooth, paper. As to the *pen*, when a steel one is used the paper always shows a distinct groove or cutting on its surface, especially at the edges of the heavy lines. When the pen is old and corroded the paper looks as though cut with a knife. Under the head of *ink* the various qualities were discussed. By the *qualifications of the writer*, the author includes his skill, method, physical ability, &c. A person much accustomed to writing usually writes at a good speed, and without hesitation. The writing, in quality, is apt to look alike at all points on the page. Where writing is done slowly it is not so regular, and the curves are not so smooth and geometrical. Where a habitually light writer attempts to make a heavy stroke, the shading is irregular. The same is true where a person accustomed to writing with a heavy stroke attempts to write lightly. These differences are such that they can be usually discovered with the aid of the Microscope; and when a writer concentrates all his faculties on the appearance and character of the writing, it never has the easy, flowing appearance which it otherwise would have. The tremor in the writing of old persons is nearly impossible to imitate. The *circumstances under which the writing was done* have as much to do with its appearance as any other cause. One who habitually uses a flexible gold pen writes very differently with a steel one. The reverse is equally true.

The practical application of these and other facts in the examination of writing requires patient investigation, much of it apart from the simple use of the Microscope, and the author agrees that in the great majority of cases the microscopical investigation is utterly useless without a corresponding outside investigation.

Dr. J. H. Wythe also read a paper † to the August (1880) Meeting of the San Francisco Microscopical Society, in which he said:—

"An article in the 'Banker's Magazine' for August 1878, refers to the value of the compound Microscope in the examination of handwriting, beyond the ordinary methods of experts, who rely upon unaided vision or a hand-lens. It shows that the conclusions of an ordinary expert are reliable just so far as they rest upon data which

* Proc. Amer. Soc. Microscopists, 1881, pp. 50–9.
† Amer. Journ. Micr., v. (1880) p. 225.

can be explained, and no farther. A man who writes his signature frequently falls into a series of rhythmical movements which are peculiar to himself. This may arise from habit or individuality of muscular organization. His general handwriting may differ in style from his signature, but the accentuation remains the same. A talented imitator may produce this general rhythm of a signature, and cause the testimony of an expert to become vague and uncertain. The expert may detect a difference, empirically, but he is unable to explain it to the satisfaction of a jury. 'It is just at this point,' says the writer, quoting from a letter to the 'New York Times,' 'where the methods of the expert break down, that the more delicate methods of optical analysis represented by the compound Microscope interpose to detect and demonstrate forgery.' In addition to the larger rhythm upon which the expert bases his judgment there is a *minute secondary rhythm* caused by the action of the small muscles in regulating the amount of pressure upon the pen, which is imperceptible to the naked eye, and cannot be accurately determined with a simple magnifier, but which is easily discerned in a compound instrument under a power of about ten diameters, if the writing is strongly illuminated with a good bull's-eye condensing lens. These variations of pressure are between 200 and 300 to the inch, and are as regular in proportion as they are spontaneous and involuntary. When a man writes naturally, the pressure variations are rhythmical, while on the contrary, when he is consciously imitating the writing of another, they are irregular and unsymmetrical. No matter how cleverly a signature may be imitated, so long as the writer exercises the voluntary control of the hand, which is essential to the act of imitation, just so long the margin of the stroke can be demonstrated optically to be irregular in the length and the distribution of the waves which indicate the muscular impulses. Thus the compound Microscope determines the issue at the point where the coarser processes of the ordinary expert fail. My attention having been called to this subject, I instituted numerous experiments, which have convinced me of the general accuracy of the article, of which the foregoing is an abridgment. Careful investigation enables me to classify the phenomena of handwriting, especially signatures, as analyzed by the compound Microscope, as follows:—

(1) The rhythm of *form*, dependent on habit or individual organization. This is the main dependence of the ordinary expert. It may be determined by the naked eye or a hand-lens, but is still more easily seen by means of the magnified image in the compound Microscope. In some cases an enlarged photograph of genuine and disputed signatures may be useful—remembering, however, that the form of letters may change from time to time more readily than the general rhythm.

(2) The rhythm of *progress*. This is the involuntary rhythm referred to above as pressure-variations on the point of the pen, and seen as a wavy margin to the letters of signatures when well illuminated on the stage of the compound Microscope. It is caused in all probability by the rapidly successive nerve-impulses upon which the contraction of the muscles depends. In age or infirmity, these impulses

are perceptible to the eye, and we say that the hand trembles. 'But as a matter of microscopic analysis the hand always trembles, and it is an inalienable property of muscular contraction that it should.' The regularity of this rhythm is destroyed by a voluntary effort at imitation, and is somewhat interfered with, but not entirely broken, by mental excitement. This rhythm differs in different handwritings, so that it is well for the examiner, if practicable, to accustom himself to the habitual rhythm of a genuine signature before expressing a judgment on one which is questioned.

The art of writing is a most complicated one, requiring the consentaneous action of many muscles. When perfectly performed, it should be nearly, if not quite, automatic, requiring very little mental stimulus for its performance. If any act which should be automatic demands our attention in order to execute it, the difficulty of performance increases. The ordinary mental stimulus suffers an emotional diversion, which causes proportional muscular impotence. Hence emotional disturbance causes a trembling handwriting. In cases of writer's cramp, in which the muscles respond but sluggishly to the will, and render the grasp of the pen faltering and uncertain, this rhythm is greatly exaggerated or interrupted. Paralysis of the ulnar nerve, rheumatism of the shoulder or wrist, neuralgia, and alcoholism, may also interfere with the rhythm of progress. But in no case is the failure of the rhythm so marked as in a voluntary attempt at imitation.

(3) The rhythm of *pressure*. By this I mean, not the involuntary and rapid action of the muscles, producing a microscopic wave as the writing progresses, but a rhythmical alternation of light and dark strokes, which is characteristic of some signatures, and which, in all probability, is a variety of the rhythm of form; yet, as it is revealed to microscopic analysis rather than to ordinary vision, it may escape the most expert imitator, and so become another factor in making up a judgment in any case.

If the microscopist carefully observes these three rhythms, being careful of the illumination of the letters, he cannot fail to demonstrate the difference between a genuine and an imitated signature.

In a recent trial before Judge Crane, in Oakland, I was able to discriminate between imitated and genuine signatures in a large number of cases of remarkable similarity, prepared by a most talented writer, as well as to testify to the genuineness of signatures in which there was considerable variation of form. Mr. Geo. C. Hickox, also a member of the Microscopical Society, and well known as an expert in such matters, when his attention was called to this use of the compound Microscope, declared to the Court that it was a new and wonderful revelation, fixing beyond question the individuality of handwriting, especially of signatures.

Should this method of investigation be much used, as it ought to be, it would be convenient to have a Microscope made for the purpose, having a large stage with clips so as to hold paper of considerable width, a tube of wide diameter to collect as much light as possible, a very low power eye-piece, and a special objective of long focus and large field of view."

Under the title of "Graphiology," Mr. C. H. Denison read a paper before the October meeting of the San Francisco Microscopical Society, on the art of writing, the detection of forgery, &c., in which he refers to the articles in the 'Banker's Magazine' and 'New York Times,' and denies that there is any basis for the theory suggested, the variations along the margin of signatures not being caused by any nerve-impulses or tremor, but, without doubt, by the uneven surface of the paper fabric, assisted by capillary attraction. No matter how well rolled or calendered the fabric, under the Microscope there are seen fibres and inequalities, and those depressions and swellings of the pulp cause the uneven edges of the ink. As a proof of that, he submitted specimens of ink-drops on paper, which had dried undisturbed (and upon the same kind of fabric as a signature he exhibited) the edges showing the same unevenness, and resembling exactly the edges of the signature. Straight lines drawn with a ruler upon the same fabric, with the same pen and with the same ink as the drops, exhibited similar edges. There are, he contends, no regular nerve-impulses perceptible, and therefore not comparable by individuality with each other, the irregularities seen on the margin of signatures being caused by some other principle than muscular rhythm or nerve-impulses.

After, however, the comparison of words and letters is finished, and the examination of the fabric upon which the signature or documen is written is begun, then the use of the Microscope is invaluable and certain. It is sure to detect any disturbance of the fabric by erasure, or addition, and becomes an important factor in the examination. No addition or erasure can be so skilfully made that the Microscope cannot detect it, seen either by the disturbance of the fabric, or the inequality of admittance of light through it.

Mr. R. U. Piper * also disputes the "rhythm" theory, and contends that upon the examination of the writing of the expert forger under the Microscope the sides of the ink strokes are generally found to be much more even (less tremulous) than those of the one they are intended to imitate; indeed, that this is often one of the very means by which the fraud is detected. A woodcut is given of pen-strokes ($\times$ 40) from the writing of three different persons.

At the March Meeting of the San Francisco Microscopical Society Dr. Wythe read a further paper on "Graphiology," in which he says that, "after considerable experience, I still maintain that if the microscopist carefully observes the three rhythms, being careful of the illumination of the letters, he cannot fail to demonstrate the difference between a genuine and an imitated signature.

"Since the presentation of the first article,† I have read some criticisms which remind me of the custom of neophytes, to whom we exhibit some interesting object in the Microscope for the first time. Instead of attending to the object shown, they will almost universally look at some flaw on the cover-glass, speck on the eye-piece, or accidental streak, and ask: 'What is that dark spot?' Some of these criticisms show plainly that their writers fail utterly to comprehend

* Amer. Journ Micr., vi. (1881) pp. 16–18 (1 fig.). † See above, p. 859.

the idea presented. One finds fault with the measurement of 200 to 300 in the inch given by the article in the 'Banker's Magazine,' and declares * that the irregularities are 'without doubt caused by the uneven surface of the paper fabric, assisted by capillary attraction.' The proofs relied upon for this opinion are the uneven edges of an ink drop, or of a line drawn by a ruler. From this the conclusion is reached that 'there are no regular nerve-impulses perceptible.' As to the number of the vibrations, I consider it a matter of but little importance whether there are six or six thousand. The point I endorse is, that there is an irregularity in the line which amounts to a rhythm. The irregularity produced by absorption of ink by the paper is so obvious, and so obviously different from the rhythm of progress, that no practical microscopist would be in danger of confounding them, and the veriest tyro would need no reminder.

"Another criticism † is accompanied by a woodcut of pen-strokes magnified forty diameters. An examination of this woodcut will convince any one of the difference between the irregularities of linear progress and the absorption of the "paper fabric." Differences in the irregularities of the lines are also obvious in the woodcut. If it had been magnified but ten times (as proposed) instead of forty, the rhythmical nature of the vibrations would have been more evident.

"In my first paper it was stated that a voluntary attempt at forgery leads to an exaggeration or an interruption of the rhythm. To the latter part of this statement the last criticism referred to lends unwitting corroboration. If all my critics follow in this line, my position will be well established. He says: 'The truth of the matter in this respect is, that upon examination of the writing of the expert forger under the Microscope we find the sides of the ink strokes much more even (less tremulous) than those of the one they are intended to imitate. Indeed, this is often one of the very means by which the fraud is detected.' If this language means anything different from the following, from my own paper, I am unable to perceive it. 'The regularity of this system is destroyed by a voluntary effort at imitation, and is somewhat interfered with, but not entirely broken, by mental excitement.' An 'expert forger' will destroy the rhythm of the impulses, rendering the line 'less tremulous' or smoother; but a bungler, or one whose conscience interferes, will exaggerate the rhythm.

"In my essay I sought to classify and so put upon a scientific basis facts relating to rhythms in handwriting, which any microscopist ought to be able to verify. On such a subject it would be absurd to seek for anything but absolute truth, however refined or difficult the search. Courteous criticism is therefore to be desired and not shunned. I desire this the more as I am now considerably advanced in the preparation of a book on this special subject, which will place the mode of examination within the reach of all interested."

At a subsequent meeting Dr. Wythe further enlarged upon his

* See above, p. 862.

† See above, p. 862.

views * and produced some specimens in illustration, consisting of five envelopes containing the same address written by different persons.

**Smoke and Steam under the Microscope.**†—L. J. Bodaszewsky calls attention to the rapid oscillatory movements which are disclosed by the Microscope in the smoke of burning paper, wood, cigars, &c., when concentrated sun or electric light is thrown upon them through a lens. The particles are of a spherical form, and they are continually darting against each other, so as to represent very strikingly the motion of gas molecules according to the kinetic theory. Similar movements are observed in the vapour of nitric, sulphuric, and phosphoric acids, sulphur, ammonia, &c., when examined under the Microscope by the light of a glowing platinum wire.

**Microscopical Representation of Physiological Movements.**‡—M. Marey has succeeded in a further development of the Graphic Method. He has given to the tracing dimensions so reduced as to justify one in neglecting the velocity of the writing pen. Taking for example a sphygmogram or a cardiogram he shows that ordinarily the curves are about 5 mm. high; supposing that the lever moves very fast and so moves too far, if we reduce the amplitude of the tracing ten times (to 0·5 mm.) the effects of the velocity would be so much diminished as to be a hundred times less than with the ordinary instruments. These tracings must, however, be taken on surfaces which move exceedingly slowly, and the details of the curve cannot then be seen by the naked eye. When magnified ten times they can be made out. Experiments thus conducted show that the tracings are identical with those given by the ordinary cardiograph and similar instruments, in which, therefore, one may place complete confidence.

The microscopic markers can also be used to mark such delicate movements as the vibrations of the blood in the vessels, and they have a practical recommendation in being very portable, and so easily used in medical practice.

* See Amer. Journ. Micr., vi. (1881) pp. 104–8. (A discussion followed the reading of the paper.)

† Dingler's Journal. See Journ. Franklin Institute, lxxxi. (1881) p. 384.

‡ Comptes Rendus, xcii. (1881) pp. 939–41.

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Vol. I. Part 6.

DECEMBER, 1881.

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# JOURNAL

OF THE

# ROYAL MICROSCOPICAL SOCIETY;

CONTAINING ITS TRANSACTIONS AND PROCEEDINGS,

AND A SUMMARY OF CURRENT RESEARCHES RELATING TO

ZOOLOGY AND BOTANY

(principally Invertebrata and Cryptogamia),

MICROSCOPY, &c.

---

*Edited by*

FRANK CRISP, LL.B., B.A.,

*One of the Secretaries of the Society*
*and a Vice-President and Treasurer of the Linnean Society of London;*

WITH THE ASSISTANCE OF THE PUBLICATION COMMITTEE AND

A. W. BENNETT, M.A., B.Sc.,
*Lecturer on Botany at St. Thomas's Hospital,*

F. JEFFREY BELL, M.A.,
*Professor of Comparative Anatomy in King's College,*

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FELLOWS OF THE SOCIETY.

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OF THE

# ROYAL MICROSCOPICAL SOCIETY.

Ser. 2.—Vol. I. Part 6.

(DECEMBER.)


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☞ *A special feature of the Journal is the classified Summary it contains of the work of British and Foreign Observers relating to Zoology and Botany (principally Invertebrata and Cryptogamia), Microscopy, &c., as appearing in the principal Journals, Transactions, &c., of this and other Countries.*

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All communications as to the Journal should be addressed to the Editor, Royal Microscopical Society, King's College, Strand, W.C.

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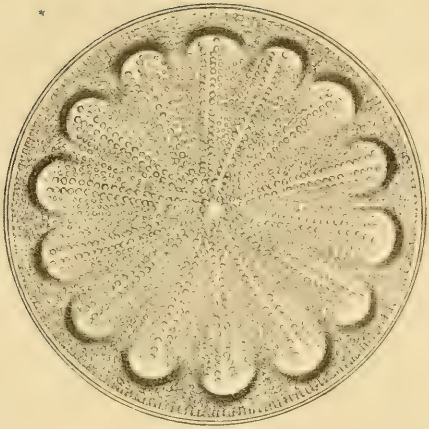

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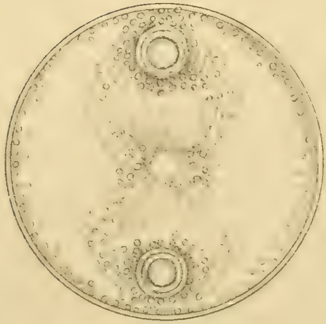

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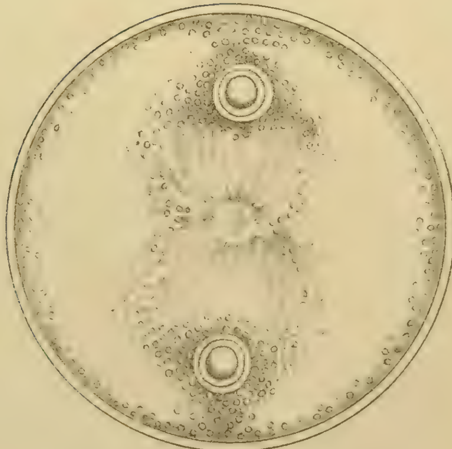

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L. G. Mills del. West, Newman & Co. lith.

Diatoms from Peruvian Guano.

JOURNAL

OF THE

# ROYAL MICROSCOPICAL SOCIETY.

DECEMBER 1881.

## TRANSACTIONS OF THE SOCIETY.

### XII.—*Diatoms from Peruvian Guano.*

By the Rev. Lewis G. Mills, LL.D., F.R.M.S., &c.

(*Read 9th November*, 1881.)

Plate XI.

For many years past it has been my custom, every winter, to make a few large preparations of Peruvian guano, for the sake of obtaining diatoms usually to be found in that deposit. I procured the supplies of the material from extensive warehouses, and from time to time, as samples of several importations.

I have observed that within the last fifteen years, certain changes have taken place as respects the diatoms to be found in this guano, and my object in writing this short paper is to point out a few of these changes, and to direct attention to a few remarkable forms that have come under my notice when mounting the slides from my many preparations.

In the first place, however, I may state a few particulars in which the guano of to-day agrees with that of fifteen years ago.

The different forms of *Coscinodiscus*, common to the guano of the past, remain constantly to be found in that of the present, and in their usual abundance. The same remark applies to the different species of *Actinoptychus*. If there be any difference, it is that the forms are now more frequent, and if anything, more perfect. *Endictya oceanica* continues abundantly prevalent. A few examples of *Aulacodiscus formosus* may now be found in almost every fair preparation. *Auliscus peruvianus* which was not unusual in the past, is now so rare, that a single valve, from a large quantity of material, would give me some surprise. I have not had a specimen from the preparations of the last six years. Two figures of this diatom were given by the late Dr. Greville in the 'Trans. Micr. Soc. Lond.,' x. (1862). *Auliscus ovalis* (Arnott), for a notice of which in Pritchard's work on Infusoria, Diatoms, &c., the editor was indebted to Mr. F. Kitton, is now much more abundant

than it has been formerly. Good examples of this diatom may be readily obtained, if picked out, by selection from the sandy sediment of the preparations. It seems to be one of those forms that, from some cause or other, does not remain long in suspension in water, but settles down quickly with the weightier sandy deposit. *Triceratium variabile* is now, I think, rarely to be found in guano.

One of the most decided and remarkable changes that I have observed in the guano of the present, is the *complete absence* of *Aulacodiscus scaber*. This diatom was formerly *very abundant*. Ralfs, in Pritchard's work, 1861, gives it as a new species from Peruvian guano. In every slide of guano of fifteen years past good specimens are very common, but in the preparations of the last eight years, and they have been many, I have not found a single example. *Aulacodiscus Comberi* is now abundant and seems to supply the place of *A. scaber*. The processes of this diatom are, upon good authority, said to be "from two to six." I have never seen a specimen with less than three, or more than four, and the frequency of the latter I take to be about one-tenth that of the former.

A few fine specimens of *Aulacodiscus Kittoni* may now be had from almost every good preparation. I have found specimens, both single and double, with six, seven, or eight processes. Before mounting this diatom it should be examined when in water, and under an objective of low power. The golden hue of the lines from the umbilicus to the processes is then marvellously beautiful.

In my last preparation of guano I met with a specimen of *A. Kittoni* which has *fourteen* processes. This is a very rare and unusual variety as, I believe, no instance has been previously known in which the processes of this diatom exceed eight in number. It is not a specimen with two valves, each containing seven processes: such a case I have known, but in that case the seven processes of one valve were only distinctly visible at once, and it was after a considerable alteration of focus that the other alternate seven came into view, and then the others had disappeared. In my rare specimen the fourteen processes and the fourteen double lines of granules from the umbilicus to the processes, *appear all at once, in the same plane, and all are equally distinctly defined*, even under an eighth-inch objective. I give a figure of this diatom, Fig. 1, Plate XI.

There is another diatom, ten or twelve examples of which I have found in Peruvian guano, to which I would direct attention. It is an *Auliscus*, and I believe it to be unmistakably a new species. I found the first specimen of this new form about ten years ago, and then I gave a rough figure of it with a brief notice in 'Science-Gossip.' Since that time I have found it persistently in my preparations. Some of the diatoms are single valves, others double.

The form to which it bears the closest resemblance is, I think, *Auliscus racemosus* Greville,* yet the differences of markings and general character are far greater than those required to mark a distinct species, and are quite sufficient, in my opinion, to give this diatom a name and a place among the fossil forms of guano. (See Fig. 2.)

The following is a description of the species:—

Valve circular, moderately large; two processes, each surrounded by a cluster of well-defined granules; umbilicus faint, with faintly radiating, curved, and partly granulated lines from umbilicus towards the processes.

I would name it *Auliscus constellatus* nov. sp. Per. guano.

Single examples of other forms, some rare and others common, may sometimes be found, but as these are to be obtained from other deposits to which they more steadily belong, and as their recurrence may not be confidently expected, they cannot be tabulated with the usual diatoms of Peruvian guano.

* 'Trans. Micr. Soc. Lond.,' xi. (1863) p. 46.

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## EXPLANATION OF PLATE XI.

Fig. 1.—*Aulacodiscus Kittoni* var. × 320.
„ 2.—*Auliscus constellatus* n. sp. × 320.
„ 3.— „ „ large specimen. × 320.

## XIII.—*Multiple Staining of Animal Tissues with Picro-carmine, Iodine, and Malachite-green Dyes, and of Vegetable Tissues with Atlas-scarlet, Soluble Blue, Iodine, and Malachite-green Dyes.* By B. Wills Richardson, F.R.C.S.I., Vice-President, University of Dublin Biological Association.

(*Read 9th November*, 1881.)

### *Animal Tissues.*

Beautiful treble stainings may be obtained with picro-carmine and iodine-green after the method described by Stirling.* I have found, however, that the iodine-green tint can be effectively varied by the addition of malachite-green, which sometimes, also, results in a quadruple staining.

A thin, evenly-cut cross section from the tail of a recently born kitten, for example, is susceptible of displaying these multiple stainings most distinctly, owing to the diversified structure of the tail.

At the meeting of the Dublin Microscopical Club held at Dr. Reuben Harvey's house, in July last, I exhibited (1) eight sections from a kitten's tail; (2) a complete cross section from the larynx of a human ninth month fœtus, and (3) a longitudinal section from an enlarged uvula I excised some months previously, with all of which the picro-carmine, iodine, and malachite-green dyes were used. The majority of the tail sections were very successfully stained in treble, the remainder in quadruple. The laryngeal cartilages were but slightly coloured by the greens, probably from insufficient exposure to their action; for I have lately procured decided stainings of sections from the same larynx, stained two years ago with picro-carmine and Ranvier's madder stain. These may be called quintuple stainings.

The uvula section showed but a slight trace of the green dyes, although exposed to their action until it seemed dark blue in colour. I have, since the meeting, tried to fix them in the mucous glands of another picro-carmine stained section from the uvula, by omitting the acetic acid washing,† and adding to the green solution a couple of drops of an aqueous saturated solution of arsenious acid.

Four of the glands, three weeks after the staining, had a rich greenish-blue tint, which has altered but little in depth of tone. The others have changed considerably, being purple rather than green.

The structures in the tail sections, for which the green dyes have an affinity, seem to be permanently stained by them. The

* 'Text-Book of Practical Histology,' p. 69. (London, 1881.)
† Ibid., p. 69.

time-test, however, has been rather short for more positive speaking upon this point.

Iodine-green, Stirling mentions,* has a great affinity for bone. Confirmatory evidence as to the accuracy of this statement is afforded by those sections in which the iodine-green exceeded the malachite in the green-stain, the recently formed bone being stained dark bluish green. The nuclei of the cartilage cells of the ossifying vertebra have a rich grey tint modified by their previous carmine colouring.

The sections exhibited at the club meeting were exposed to the action of watery solutions of iodine and malachite-green dyes, in different proportions, until they seemed dark blue in colour, in the hope of obtaining stainings in varied shades of green, from the nearly pure malachite to the deeper iodine-green.

These experiments had the following results:—

1. Picro-carmine stained section placed in equal parts of the iodine and malachite-green solutions, diluted with water to make them slightly transparent, shows the cartilage cells' nuclei of a light purplish grey, the newly formed osseous walls of the cancellous tissue being dark bluish green of extreme richness.

2. Picro-carmine stained section—placed in the same green fluid—in which ossification of the cartilage seemed completed; the walls of the cancellous tissue are similar in tint to those of No. 1, but the spaces themselves are filled, almost without exception, by gorgeously coloured corpuscles, in ruby and yellow. Outside or bounding these central stainings of Nos. 1 and 2, many of the other component structures of the section are differentiated with much distinctness in picro-carmine and green, viz.: sections of muscles, of tendons, and of hairs in their follicles. In some of the follicles, two shades of green are visible, rendering these sections quadruple stainings.

3. Picro-carmine stained section placed in a slightly diluted mixture of the green dyes, in which the malachite was slightly in excess; the bone is dark bluish green at its circumference, the latest formed bone being a lighter green. The other structures of the section resemble Nos. 1 and 2 in colouring.

4. Picro-carmine stained section submitted to the action of the malachite-green only; the new bone is stained light green, but, to my eye, it is not so strikingly effective a colour by transmitted light, as the mixed green colouring of the other structures.

The hairs and hair follicles are a lighter green in tint than in the other sections. In a few follicles some of the layers are a delicate blue, rendering this section likewise, a quadruple staining.

I had better observe that in staining animal tissues with iodine and malachite-green dyes, when the sections have become tolerably

* 'Text-Book of Practical Histology,' p. xlvi.

dark blue in appearance, wash them rapidly in spirit of wine to remove superfluous green, then let them lie in absolute alcohol for a few minutes to remove water, and mount in Klein's dammar solution.

Stirling recommends that the stained sections should not be left too long in the spirit, which partially removes the dye.* The same precaution, I should remark, must be taken with the malachite-green stain, either alone or combined with iodine-green. I have found from five to ten minutes amply sufficient for the purpose.

### *Vegetable Tissues.*

Strikingly beautiful as sections of some animal structures undoubtedly are, when successfully stained with picro-carmine, iodine and malachite-green dyes, sections of many vegetable tissues are also susceptible of very fine double staining, and occasionally of fine treble staining with atlas-scarlet, soluble blue, iodine and malachite-green dyes.

Let sections cut from the recent stems lie in spirit of wine for about a fortnight, but when not required for immediate observation, store them in Price's glycerine for a couple of months, which renders them, when dammar mounting, not so liable either to fold or break as they are when stained immediately after cutting.

I shall now, for brevity sake, direct a section of palm stem to be taken through one of these staining processes.

Place the section in a bottle containing a tolerably dark-tinted solution of atlas-scarlet in spirit of wine. Leave it in this solution (corking the bottle tightly) until it has become of a uniform scarlet tint. But like sections of animal tissues undergoing the double staining process in scarlet and blue, which I have already described,† the section may be left in the scarlet solution for many weeks without risk of counteracting the energy of the green dyes.

I have recently found in my collection, a store bottle containing sections of the spinal cord which had been lying in atlas-scarlet solution for more than twelve months. I submitted a few of the sections to the action of the soluble blue and obtained very perfect double stainings in scarlet and blue, proving that the second stage of the process, the blue staining, may, with but little risk of failure, be almost indefinitely postponed.

I do not, however, wish to speak positively regarding the conduct of atlas-scarlet with iodine and malachite-green dyes in multiple stainings of vegetable sections, and think it better to recommend the completion of the process when the sections seem coloured deep scarlet.

Should the section have the desired scarlet depth of colour,

* 'Text-Book of Practical Histology,' p. xlv. † *Ante*, p. 573.

wash it in filtered water to remove superfluous scarlet loosely adhering to the surface, until the water ceases to be in the slightest degree coloured by it. Transfer the section to a half-ounce white porcelain saucer containing spirit of wine coloured bluish green with a couple of drops of aqueous saturated solutions of the green dyes. A drop of each dye about the proper proportion.

When the section seems dark blue in colour, transfer it to water in another saucer containing a trace of an aqueous saturated solution of arsenious acid, or of a solution of oxalic acid in water (one grain of the acid to an ounce of water), or of glacial acetic acid in water. Wash by rotating the saucer. Then place the section in absolute alcohol, likewise containing a trace of either of the above-named acid solutions.

When water has had time for removal by the alcohol, which requires from about ten to fifteen minutes, transfer to slide, clear with clove oil, and mount in Klein's or in one of the other dammar solutions.

The sections of stems submitted to the experiments were cut from the recent stems of (1) sugar cane; (2) palm; (3) clematis; (4) buckthorn; (5) Ficus Sycamorus and (6) bignonia, all of which were placed at my disposal by my friend Mr. Frederick William Moore, the accomplished curator of the Glasnevin Botanic Gardens, near Dublin.

I have found in practice that sugar-cane sections are most manageable after immersion in the glycerine for several months. These sections, I think, will work more satisfactorily with the atlas-scarlet * and soluble blue than with this scarlet and the green dyes. Should, however, the latter fly, a very beautiful staining in scarlet will remain. (Since this communication was put in type I have successfully stained cane sections in treble, thus :—(1) Atlas-scarlet staining and washing, (2) soluble blue staining and washing in water acidulated with the glacial acetic acid, and (3) iodine and malachite-green staining.)

Sections of palm are more easy to stain with atlas-scarlet and the green dyes than the sugar-cane sections, these dyes forming exquisitely coloured differentiations of structure in the palm.

Clematis sections generally come out of the final staining process coloured in treble, and sometimes the structures stained scarlet in one section may in another be coloured green.

Buckthorn sections are usually distinctly differentiated in scarlet and green.

Ficus Sycamorus sections seem to have a great affinity for the green stains, a couple of minutes' exposure to their action being nearly sufficient for the completion of the treble staining, and although the green colourings occupy the greater portion of each

* See *ante*, p. 573.

section, the scarlet staining being mostly central, renders the differentiation most effective. In each of these sections the walls of the central cells are green, their contents light scarlet.

The atlas-scarlet and mixed green dyes, the malachite being in excess, double stain sections of potato with most precise differentiation, the starch-grains in rich green, the loculi in scarlet; the depth of colour depending upon the length of exposure to the staining solutions. Each staining should be carried out separately, washing in water containing a trace of a very dilute sulphuric acid. These sections also, should be mounted in dammar solution.

With the exception of the picro-carmine, the colours mentioned in this communication were obtained from Messrs. Brooke, Simpson, and Spiller, 50 Old Broad Street, London.

# SUMMARY

OF CURRENT RESEARCHES RELATING TO

# ZOOLOGY AND BOTANY

*(principally Invertebrata and Cryptogamia)*,

# MICROSCOPY, &c.,

INCLUDING ORIGINAL COMMUNICATIONS FROM FELLOWS AND OTHERS.*

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## ZOOLOGY.

### A. GENERAL, including Embryology and Histology of the Vertebrata.

**Mesoblast of the Vertebrata.**†—Dr. O. Hertwig here gives the first part of his full account of his studies on this subject, the preliminary notice of which we have already noted.‡ He points out that the object is to confirm the view enunciated by his brother and himself in their tract on the cœlom theory, in which they urged that the middle layer of the Craniota arose, just as in the Chætognatha, the Brachiopoda, and in *Amphioxus*, from the epithelium of the archenteron. The present part deals with holoblastic ova, the first example of which is *Triton tœniatus*, a form admirably adapted for embryological investigation, especially when the ova are artificially fertilized; as the spermatozoa of this form live with difficulty in water, the author recommends their being transferred to 1 per cent. salt solution, to the serum of the body-cavity, or to dilute aqueous humour. After a full description of his method Dr. Hertwig proceeds to divide the history of the development of the germinal layers into four periods.

In the first of these we have the formation of the blastula and gastrula; in the latter there appear at some distance from the vegetative pole a small pit, which is the first sign of the commencing invagination, and at the sides of the vegetative pole, and a little later, a horseshoe-shaped groove—the mouth of the gastrula; the gastrula soon becomes bilaterally symmetrical, and the yolk takes up a ventral position. During the whole of this period there is a continuous and considerable superficial increase of the cell-membrane of the blastula; this is either effected by the growth and extension of the animal cells, or by the increase and extension of the yolk-cells.

* The Society are not to be considered as responsible for the views of the authors of the papers referred to, nor for the manner in which those views may be expressed, the main object of this part of the Journal being to present a summary of the papers *as actually published*, so as to provide the Fellows with a guide to the additions made from time to time to the Library. Objections and corrections should therefore, for the most part, be addressed to the authors. (The Society are not intended to be denoted by the editorial "we.")

† Jen. Zeitschr. f. Naturwiss., xv. (1881) pp. 286–340 (4 pls.).

‡ *Ante*, p. 575.

Before the completion of the gastrula-stage certain changes have taken place in the region of the blastopore, which are connected with the formation of the mesoblast; the blastopore loses its rounded form and becomes a narrow and deep cleft, which lies in the long axis of the embryo. On the surface of the egg there appear three grooves; on either side two semilunar grooves gradually increase till they unite ventrally with one another. In front of the blastopore the surface of the egg is depressed to form a small groove which lies in the long axis of the egg, and corresponds to the primitive groove of the Amniotic Vertebrates. A study of the sections made during this period has convinced the author that the mesoblast-stripes always arise in the form of at least two-cell layers, one of which passes into the chorda-endoblast and the other into the enteric-endoblast. No elements are given off from the endoblast, for this, even in the gastrula-stage, forms a single layer of cylindrical cells. The mesoblast does not arise in the form of isolated cell-aggregates, but as two masses of connected cells; these bands first appear in the region of the blastopore and on either side of the chorda-endoblast, whence they gradually extend over the surface of the egg, and, uniting, separate the two primary germinal layers. This layer owes its origin to a paired outgrowth of the endoblast, which commences to be formed before the gastrula-stage is completed; and, in short, we see that in the triton, as in the other groups previously cited, the archenteron is by two folds broken up into a central space, which forms the permanent enteron, and into two lateral diverticula or body-sacs.

The third period is characterized by the formation of the *chorda dorsalis* and the separation of the two mesoblast-sacs from the primary endoblast.

The fourth period of the development of the mesoblast is characterized by the formation and growth of the primitive vertebræ and the differentiation of the musculature of the body. The former shows that there is a very intimate connection between the closure of the enteron on its dorsal surface, the separation of the two mesoblast-sacs from the endoblast, and the development of the *chorda dorsalis* from the chorda-endoblast. In the latter the two cœlom-sacs, by a process of successive foldings, give rise to the primitive vertebræ; this commences in the cervical and gradually extends to the caudal region. The epithelial wall of the cœlom gives rise to transverse folds, and the successive diverticula thus formed communicate for some time with the sac of the cœlom; later on, these diverticula become completely shut off, and then form saccules on either side of the notochord; in other words, these primitive cavities are parts cut off from the primary cœlom.

**Experiments on the Origin of the Difference between the Sexes.***—Dr. G. Born's experiments were made on the brown grass-frog, ova being artificially fertilized and placed in twenty-one distinct

* Breslauer ärztliche Zeitschr., 1881, No. 3 & foll. Cf. Kosmos, viii. (1881) pp. 65–6.

roomy aquaria. In five of the vessels the brood consisted entirely of females; in six more the proportion of the same sex was from 91·5 to 96 per cent. In but two aquaria was any considerable number of males produced, viz. 13 per cent. in the one, and 28 per cent. in the other; whereas in nature the number of males is about the same as that of females. The cause of this phenomenon appears to be that artificial conditions tend, by the smaller quantity of food thus supplied, to favour the development of the weaker sex, which thus predominated; this view is enforced by the circumstance that the aquarium in which the greatest number of males was produced, had been accidentally inundated with muddy water, which probably contained a large amount of nutriment in the form of minute organisms, such as Rotifera, Infusoria, and Algæ, by which encouragement was given to the development of the stronger sex. This result is the converse of that arrived at by Prof. Hoffmann, of Giessen, who found that deficiency of nourishment resulted, in the case of plants, in the production of an excess of males.

**Cochlea of the Monotremata.***—Dr. Urban Pritchard has been enabled to extend his investigations into the minute structure of this organ by an examination of *Ornithorhynchus platypus*. The cochlea is a somewhat curved tube, about $\frac{1}{4}$ inch in length, and $\frac{1}{20}$ inch in diameter; when compared with that of typical Mammals and of Birds we find that it has much more resemblance to the latter. Thus the cochlea of both Duckbill and Bird consist of curved tubes, enlarged at their anterior extremities, with not much difference throughout except at their apex. On the other hand, when we come to examine the interior its agreement with the Mammalian type is well marked; the chief differences appear to be that in *Platypus* the *scala vestibuli* is throughout larger than the *scala tympani*, whereas in the typical Mammal the two are, for the most part, much of the same size. In the membrane of Reissner the epithelial cells are thicker than in the typical cochlea, but there is, in addition, another point of difference in the presence of "blood-vessels running across the membrane from lamina to ligament, forming here and there convoluted knots;" these seem to have never yet been observed. The organ of Corti has much the usual characters, but the rods stand more upright, and the extremities are not so well developed. The author has not been able "to make even an approximate calculation of the number of rods or bristle cells, but there must be a much fewer number of these in the duck-bill's cochlea than in that of the ordinary mammal." The presence of a lagena at the end of the Monotrematous cochlea is a curious point, which, while showing a resemblance to the Bird is, as the author reminds us, "a link between the cochlea of the higher and lower Vertebrates, and not merely between that of the Mammal and Bird."

On the whole, then, the organ of Corti is not nearly so extensive as in typical Mammals, and the various minute structures of which it is made up, do not seem to be so well developed.

* Phil. Trans. clxxii. (1881) pp. 267–82 (1 pl.).

**Balfour's Comparative Embryology.***—It is impossible to speak too highly of this book, now completed by the issue of the second volume. Students of embryology will no longer have to depend upon unearthing the various papers relating to the subject from the scattered pages of a mass of periodical literature, but have now for the first time ready to hand an invaluable guide to all the researches of embryologists throughout the world. These have been summarized, systematically arranged, and worked up into a connected whole, with the addition throughout of the author's own original observations, at an expenditure of labour unsurpassed in any zoological work of recent times. The Invertebrata are dealt with in the first volume and the Vertebrata in the second; and besides numerous figures there is a copious classified bibliography which is of very great practical value.

## B. INVERTEBRATA.

### Mollusca.

**Vessels of the Ink-bag of Cephalopoda.**† — Continuing his researches on the ink-bag of the Cephalopoda,‡ P. Girod proceeds to consider its vascular supply. The arteries are derived from the anterior aorta, the veins from the "large vein." In *Sepia officinalis*, which fairly represents the condition of this system in the whole group, the anterior aorta sends out, from a point only 1 mm. from its origin, an artery, the *artery of the gland*, which dips downwards, runs along the upper side of the bag, and at 10 mm. from its lower end divides into five or six vessels, which enter its wall and break up in the trabeculæ of the ink-gland. An intestinal branch and a number of twigs supplying the posterior surface of the sac are given off by the artery of the gland before it sinks into the wall. After sending out this vessel the anterior aorta, in passing the front wall of the sac, sends out another branch, the *artery of the wall*, which covers the wall of the sac with its ramifications, then ascends, sending four branches to the vesicle or excretory sac, and numerous other ones to the duct, the rectum, and the anus. The supply of the vesicle is thus quite distinct from that of the ink-gland.

There are two sets of veins; the deeper ones take the blood from the internal coat of the bag and of the gland, and unite to form the *vein of the gland* which becomes attached to the artery of the gland; the second set, or *veins of the wall*, arise from the surface of the vesicle and duct, in the former case proceeding to join a larger vein on the right, in the latter to behave similarly on the left.

The ultimate ends of the two sets of vessels show different modes of distribution in different genera, but in all the chief stem or its branches penetrate the trabeculæ, and break up in the limiting membrane of the gland. The main part of the capillary system lies within

* Balfour, F. M., 'A Treatise on Comparative Embryology.' Vol. I., xi, 492 and xxii pp. and 275 figs.; Vol. II., xi, 655 and xxii pp. and 429 figs. (8vo, Macmillan, 1880–1.)

† Comptes Rendus, xcii. (1881) pp. 1241–3.

‡ See this Journal, *ante*, pp. 227 and 586.

the trabeculæ; the arterial vessels are twisted, and wrapped round each other and the venules, while the latter are, on the contrary, straight; a capillary network with very narrow meshes immediately underlies the epithelium.

**Chemical Composition of the Ink of Cephalopoda.***—The same author here adds to his observations on the ink-bag an account of the composition of the ink of *Sepia officinalis*. It is odourless, slightly saline in taste, alkaline in reaction. Under the Microscope it is seen to contain a number of minute corpuscles floating in transparent serum, and manifesting Brownian movements when placed in fresh water. Of 100 parts of ink, the constituents are:—

| | | |
|---|---|---|
| Water .. .. .. .. .. .. .. .. .. .. .. | 60 | parts. |
| Mineral substances .. .. .. .. .. .. .. .. | 8·613 | " |
| Insoluble organic substances .. .. .. .. .. | 30·536 | " |
| Extractive matters .. .. .. .. .. .. .. .. | 0·851 | " |

The mineral substances, as determined after calcining, include calcium, magnesium, sodium, potassium, iron, and the acids, carbonic, sulphuric, and hydrochloric acid, the absence of phosphoric acid being noteworthy. After drying the ink, treating it first with alcohol, then with ether, then with glacial acetic acid, subsequently washing and leaving for some time under the action of alkaline carbonate of potash, and again washing and digesting with hydrochloric acid, the extractive, albuminous, and mineral matters and the mucin were removed, and a homogeneous black powder with a greenish metallic lustre remained, insoluble in water, alcohol, ether, the alkalies, and the acids (nitric acid, however, yields a mahogany-coloured solution, with evolution of reddish vapours); it is bleached by chloride of lime and chlorinated water. Acids and alkalies cause a kind of precipitation of the suspended particles of pigment; it gives off ammonia when heated in presence of soda-lime; it contains carbon, hydrogen, and nitrogen in the proportions:—$C = 53 \cdot 6$ to $53 \cdot 9$, $H = 4$ and a fraction, $N = 8 \cdot 6$ to $8 \cdot 8$; results which agree closely with those of Heintz and others.

**Development of Neritina fluviatilis.**†—F. Blochmann gives an account of the earlier stages in the history of this Fresh-water Prosobranch, which resembles the marine forms in having a large number of eggs laid in one cocoon; these cocoons are not, however, connected together. In its cleavage state it presents much the same characters as other Gastropods, but it is distinguished by the extraordinary regularity of its separate stages. The first four equal blastomeres give rise at the animal pole to the ectoderm, and from one of them there is separated off a large cell, which, itself dividing, gives origin to the mesodermal bands. The three other cells give off cells which by dividing go to form the enteron; the first four cells, richly laden with protolecithin, long retain their original form and position, and at last give rise to the liver. The author points out that there is here,

* Comptes Rendus, xciii. (1881) pp. 96–9.
† Zeitschr. f. wiss. Zool., xxxvi. (1881) pp. 125–74 (3 pls.).

as is so frequently the case with the Gastropoda, a holoblastic egg; the peculiar characters of its first four cells recall, however, to mind the meroblastic arrangement, and on the whole it would seem to be an interesting intermediate condition.

After pointing out the striking resemblances exhibited by many Gastropoda in the early history of their ectoderm, the author directs attention to the fact that Hallez has described a very similar process in the Turbellaria. The bilateral character of the development of the mesoderm is insisted on, and its occurrence in allies is also noted. The closure of the blastopore, and the later development of the mouth at the same point, was observed. The gastrula itself is formed by epiboly, in its essential characters, but on the other hand it presents some approach to the embolic method. It is true that the ectoderm grows around the whole of the egg; but it is just as true that the endodermal cells are budded off in a manner which can only be regarded as a modified process of invagination. The absence of a cleavage-cavity is an epibolic feature; and so it follows that *Fusus*, *Neritina*, and *Natica* present a series of intermediate forms leading to the well-marked emboly of *Paludina;* and we have in the Prosobranchiata an intermediate condition between the Pteropoda, whose gastrula is always formed by epiboly, and the Pulmonata and Heteropoda, where the typical method is by emboly.

The early appearance in *Neritina* of some organs, and especially of the velum, is regarded as being analogous to the facts which have been reported of the marine Prosobranchs; the cells which become grouped around the animal pole are possibly those which become the velar cells. Both in *Planorbis* and in *Neritina* two kinds of cells can be made out in the wall of the archenteron; some are richly laden with protolecithin, while others are free from this body, and have the appearance of mesodermal cells; some similar characters have been noted in the Pulmonata.

**Locomotor Organs of Cyclostoma elegans.***—In continuation of his researches, Dr. H. Simroth deals here not only with the above form, but gives a general account of his studies on all the German Gastropoda.

With regard to the former, we find that, as compared with *Paludina*, it exhibits a marked concentration of the cells of the pedal nervous system in the two pedal ganglia; there are no peripheral commissures, but between the ganglia there is a second commissure, the presence of which can hardly be taken as an indication of anything but a metameric arrangement. In his second part, the author shows that the elongation of the foot is effected by longitudinal muscles; in the Prosobranchiata and Branchiopneusta the undulatory action is irregularly distributed over the whole foot; the pedal nerves have only one branch in the foot. The Pulmonata are provided with a sympathetic plexus, and the undulatory movements exhibit a well-marked transverse arrangement.

* Zeitschr. f. wiss. Zool., xxxvi. (1881) pp. 1–68 (1 pl.).

**Innervation of the Heart, and Influence of Poisons on Lamellibranchiata.***—E. Yung commences by pointing out that the softness of their tissues, the delicacy of the walls of their vessels, and the extreme reduction of their nervous system, are considerable obstacles to the study of the physiological processes of Lamellibranchs. He describes the heart as being provided with fibres from the posterior or branchial ganglia, which accelerate the cardiac movements by increasing the number of the pulsations. Electricity, applied directly to the heart, only produces a local effect; the portion of muscle between the poles is arrested in its contractions, but the remaining mass of the heart continues to beat. No real change appears to be effected by removing the heart from the influence of the œsophageal or the pedal ganglia; elevation of temperature quickens its movements, up to 40° C.; fresh water somewhat rapidly kills them. Curare, when in a weak solution, appears to have no effect; but when very strong, it slows, though without absolutely stopping, the movements of the animal; it would seem to have no direct action on the heart. Strychnine has but a temporary effect; whatever be the dose, it only provokes some convulsive movements in the muscles of the siphon and edge of the mantle, and never gives rise to any true tetanus. A feeble dose of nicotine acts as an irritant, a strong one kills; under its influence the heart increases considerably in volume. Digitalin only acts on the heart when it is brought into direct contact with it, and it then diminishes the number of pulsations. Upas antiar has, similarly, no action on the heart unless brought into direct contact with it, when it produces a paralysis. Sulphocyanide of potassium in a strong dose stops the heart in diastole, and completely kills it. *Anodonta anatina*, *Solen ensis*, and *Mya arenaria*, were the chief subjects of experiment.

### Molluscoida.

**Development of Doliolum.**†—B. Ulianin, after describing the formation of the ovum of this little-known form of Tunicates, states that a delicate cuticular membrane is formed by the cells of the egg-follicle, which persist until the appearance of the fully formed *Doliolum*. Cleavage is at first regular and complete; after a time it becomes irregular, and goes on much more rapidly on one than on the other side of the egg. Invagination was occasionally observed, but the author does not wish to speak definitely as to the mode of gastrulation.

In the next observed stage the larva had become provided with a tail; the extended envelope was seen to contain a sausage-shaped body, the greater part of which consists of a uniform cellular mass, the rudiment of the future nervous system. On either side of this mass there is a mesodermal plate which passes into the tail; the axis of the latter is already occupied by the characteristic chorda-cells. At the anterior end of the body there is a small vesicular enlargement of the ectoderm, which is about to be converted into the provisional anterior ectodermal vesicle. As the tail in-

* Comptes Rendus, xciii. (1881) pp. 562–4.
† Zool. Anzeig., iv. (1881) pp. 473–6.

creases in length the larva takes on the form of a *Cercaria;* the mesodermal cells of the tail are converted into spindle-shaped muscle-cells, and the tail commences to exhibit its function as a locomotor organ; at the same time the mesodermal plates of the body of the larva exhibit metameric segmentation. At this stage the provisional anterior vesicle, which disappears as rapidly as it is formed, is developed. A second vesicle is formed somewhat later between the body and the tail; its development divides the mesoderm of the larva into two halves, one of which remains in the tail in the form of distinct muscle-cells, while the other forms metameric plates on either side of the body of the larva. During the whole time of its presence the tail appears to undergo no change. The nervous system which, up to this time, had extended throughout the whole length of the body, breaks up into a hinder thinner and an anterior thicker part. The invagination of the ectoderm, to form the egestive orifice, pushes the hinder part nearer to the long axis of the body, and this hinder part continues to diminish in size through all the later stages of development, till it is at last converted into the nerve which supplies the gill-lamellæ and the nutrient canal, while the anterior and thicker part gives rise to a ganglion.

The tactile cells are developed at a somewhat later period, and the so-called auditory organ is, later on, formed from a battery of the tactile cells. The gill-lamella is formed by the fusion of the anterior and posterior invaginations of the ectoderm, and the clefts begin to be formed before the muscular bands are completely differentiated. The rosette-shaped organ is formed by four outgrowths of the endoderm of the ventral surface, which are met by corresponding invaginations of the ectoderm; the former, in course of time, becomes separated from the rest of the endoderm. The mesodermal plates give rise to muscles, and the heart, with the pericardium and blood-corpuscles. After all the organs of *Doliolum* are more or less developed the tail begins to undergo atrophy; muscular contractions bring about a closer apposition of the chorda-cells, the tail gets shorter, the ectodermal vesicle smaller, until at last all sign of the appendage completely disappears from without. Within, a cell-mass formed of chorda-cells, with smaller muscle-cells imbedded in it, and presenting a resemblance to the elæoblast of the Salpæ, is for a short time present. When the tail disappears, the muscles begin to exhibit activity, and soon, the egg-covering disappearing, the larva is set free.

Celleporæ from the 'Challenger.'*—Mr. Busk describes 27 species of *Celleporæ* believed to be new, collected by the 'Challenger' Expedition. The figures, which are of great importance in this difficult genus, will appear in the official Monograph of the 'Challenger' Bryozoa. One species was brought up from a depth of 2600 fathoms in the Australian region, and another from 1325 fathoms in the South Pacific, but Mr. Busk says that, on the whole, the genus as represented in the present collection would appear to belong to comparatively shallow water. The author divides the

* Journ. Linn. Soc. (Zool.) xv. (1881) pp. 341–56 (4 figs.); ib. pp. 357–62 (2 pls. and 7 figs.).

*Celleporæ* into Holostomatous, viz. those in which the orifice is not sinuated or notched, and the Schizostomatous, viz. those in which the orifice is notched or sinuated in front.

A very important supplementary paper is added, in consequence of Mr. Busk's attention being subsequently called to Mr. Waters' paper on "The Use of the Opercula in the Determination of the Cheilostomatous Bryozoa"; and the idea then originated is carried somewhat farther by an examination of the avicularian chitinous mandibles, and figures and plates of the oral and avicularian covers are given. Mr. Busk writes, "I have become convinced that the characters derived from the chitinous organs will be found of the greatest possible utility," and he considers that in *Cellepora*, *Retepora*, and *Salicornaria*, the characters derived from these parts of the skeleton will prove almost alone sufficient to determine specific distinction. In the *Celleporæ* there are often several kinds of avicularia, but a small one, usually called the oral avicularium, is universal; the others Mr. Busk calls adventitious and vicarious. The former occur on special adventitious processes, and the latter occupy the place of a zoœcium, and are at present known as zoœcia avicularia.

Two points of structure in the avicularian mandible, to which attention is called, are the foramina, and in the holostomatous section, a minute slender projection rising from the middle of the transverse bar forming the base of the mandible. Many will, however, find the great interest of the paper to be the direction of the work, as adding the high authority of Mr. Busk for the modern use of the oral aperture as the most important character, so that the mode of examination and classification will become more uniform.

**'Challenger' Bryozoa from Marion Islands.***—Mr. J. R. Y. Goldstein describes five new species of Bryozoa from the South Indian Ocean, distributed in Melbourne by the officers of the 'Challenger,' and these he considers it better to describe at once rather than wait for the official publication of the Expedition, although thereby work in print may be anticipated.

The author expresses partial dissatisfaction with Mr. Hincks's recent classification, as he considers that it does not leave a place for all the Australian forms, but there is another way in which Australian authors may look upon the question, for by Mr. Hincks's work they are shown the way in which the Australian fauna must be examined, and instead of scanty and insufficient descriptions, we are now, as in the paper under consideration, getting scientific descriptions upon which changes in the classification can be based.

One new genus, *Malakosaria*, represented by *Malakosaria pholaramphos*, is created for forms closely allied to the genus *Elzerina* of Lamouroux, which Mr. Goldstein is inclined to consider synonymous with the later genus *Farciminaria* Busk. *Malakosaria* is defined as "Zoarium chitinous, flexible, cells raised, flat, rounded, or tubular, *not* bounded by raised lines."

* Proc. Roy. Soc. Victoria (read June 1881), 8 pp. (2 pls.).

**Fossil Diastoporidæ.***—Mr. Vine continues his notes on the Diastoporidæ, and describes and figures four Jurassic species, one of which he considers may have been described by Quenstedt and Dumortier.

The author finds himself in considerable difficulty concerning the classification, seeing that the 'History of the Marine Polyzoa' by Mr. Hincks has appeared since the review of the Diastoporidæ was commenced. The Berenicea and Diastopora of Lamouroux have frequently been used as synonymous, but Mr. Vine proposes to call the simple Diastoporæ of Milne Edwards—Diastopora; the enveloping or laminated forms—Berenicea; and the biserial—Mesenteripora.

In order to fully appreciate the bearing of this, we must remember that in the Cyclostomatous Bryozoa hardly any characters have been found upon which generic classification can be based, whereas in the Cheilostoma several are now recognized, and as these characters have been more fully studied it has been found that the classification must be less and less based upon the form of the colonial growth. This being the chief character used in the Cyclostomata, we may conclude that they are only yet empirically arranged, and therefore remarks upon the classification of a small series of fossil forms may only mean that the author finds such a system the most convenient in arranging his specimens. While it is well to know what careful and conscientious workers believe they find the most natural, both author and readers must look upon present arrangements as only tentative.

**Carboniferous Fenestellidæ.**†—Mr. G. W. Shrubsole has previously announced that he considers the number of species of *Fenestella* must be largely reduced, and, in continuation of his former papers, now describes six prominent species, giving at the same time the twenty-seven synonyms under which they had previously been known. He also gives a comprehensive description of the genus *Fenestella*, which has been described by various palæontologists with reference only to the period they had under discussion.

The author finds *Palæocoryne*—supposed to be a Hydrozoan—only on one species, viz. *Fenestella nodulosa*, and on that usually on the front or pore-face; and this, Mr. Shrubsole considers, explains the reason why it is so difficult to obtain the pore-face of this species, as, with the projecting *Palæocoryne* on the front, it has naturally been more firmly held to the shale. The discovery that some species of *Glauconome* possess a fenestrate zoarium is alluded to, and it is pointed out that this considerably complicates the question of the nature and relationship of the palæozoic Bryozoa, and possibly both genera possessed the denticulate aperture.

### Arthropoda.

**Colour-Sense in Insects and Crustacea.**—At the Jubilee meeting of the British Association, Sir John Lubbock described experiments he has made on the colour-sense of some of the lower animals. In the course of his remarks he said:—" Most botanists are now agreed that insects, especially bees, have played a very important part in the

* Quart. Journ. Geol. Soc., xxxvii. (1881) pp. 381–90 (1 pl.).
† Ibid., xxxvii. (1881) pp. 178–89.

development of flowers. While, in many plants, almost invariably with inconspicuous blossoms, the pollen is carried from flower to flower by the wind, in the case of almost all large and brightly coloured flowers this is effected by the agency of insects. In such flowers the colour, scent, and honey serve to attract insects, while the size and form are arranged in such a manner that the insects fertilize them with pollen brought from another plant. Nevertheless, these views have not escaped criticism. M. Bonnier, for instance, has attempted to show that they are in many respects untenable. I do not propose on the present occasion to follow his general argument, but merely that portion of it relating to colour.

In order to test whether and how bees are affected by different colours, I tried the following experiment. I took slips of glass of the size generally used for slides for the Microscope—viz. 3 inches by 1 inch—and pasted on them slips of paper, coloured respectively blue, green, orange, red, white, and yellow. I then put them on a lawn in a row about a foot apart, and on each put a second slip of glass, with a drop of honey. I also put with them a slip of plain glass with a similar drop of honey. I had previously trained a bee to come to the spot for honey. My plan then was, when the bee returned and had sipped for about a quarter of a minute, to remove the honey, when she flew to another slip. This, then, I took away, when she went to a third, and so on. In this way I induced her to visit all the drops of honey successively. When she had returned to the nest, I transposed all the upper glasses with the honey, and also moved the coloured glasses. Thus, as the drop of honey was changed each time, and also the position of the glasses, neither of these could influence the selection by the bee. In recording the results, I marked down successively the order in which the bee went to the different coloured glasses. For instance, on the first journey from the nest the bee lit first on the blue, which, accordingly, I marked one; when disturbed from the blue, she flew about a little, and then lit on the white; when the white was removed, she settled on the green, and so successively on the orange, yellow, plain, and red. I repeated the experiment 100 times, using two different hives, and spreading the observations over some time, so as to experiment with different bees and under varied circumstances. The precautions taken seemed to me to have placed the different colours on an equal footing; while the number of experiments appears sufficient to give a fair average. The different series agree well among themselves. The difference between the numbers is certainly striking. Adding together 1, 2, 3, 4, 5, 6, and 7, we get 28 as the total number given by each journey; 100 journeys therefore, give a total of 2800, which, divided by seven, would, of course, if no preference were shown, give 400 for each colour. The numbers, however, are, for the blue, only 275; for the white, 349; yellow, 405; red, 413; green, 427; orange, 440; and plain glass as many as 491. A second mode of testing the result is to take the percentage in which the bees went respectively to each colour—first, second, third, and so on. It is found that out of a hundred rounds the bees took the blue as one of the first three in 74 cases, and one of the last four only

in 26 cases; while, on the contrary, they selected the plain as one of the first three in only 25 cases, and one of the last four in 75 cases. On the whole, then, it seems clear that bees are affected by colour, and that their favourite colour is blue."

M. Paul Bert has made some interesting experiments on the small fresh-water crustacean belonging to the genus *Daphnia*, from which he concludes that they perceive all the colours known to us, being, however, specially sensitive to the yellow and green, and that their limits of vision are the same as ours; but Sir John, as the result of his own experiments with *Daphnia* under different parts of the spectrum, considers that the limits of vision of *Daphnia* do not, at the violet end of the spectrum, coincide with ours, but that, like the ant, it is affected by the ultra-violet rays.

### α. Insecta.

**Beetle with Proboscis like that of Lepidoptera.***—H. Müller is moved to return to this subject,† by the opinion which Dr. H. A. Hagen, of America, has expressed, of the improbability of the truth of his conclusions. He admits the purely theoretical character, in the present state of our knowledge, of the hypothesis which derives the Lepidoptera from the Trichoptera, but his object in appealing to the sudden transition to the Lepidopteran type of mouth in the case of the beetle was intended, not to prove a similar suddenness of transition from the Phryganeid mouth, but the possibility of a less prolonged series of intermediate stages between this mouth and that of the Lepidoptera than would otherwise appear to be probable.

The lengthened mouth-parts of some Phryganeidæ only serves, he says, to aid his theory. From the fact that the twenty-six American species of the beetle in question (*Nemognatha*) have prolonged maxillæ, while in the six Old-World species, these are of the normal Coleopteran structure, he deduces in support of his theory: (1) that the New World are derived from the Old World forms in this case, and hence (2) from common ancestors; (3) that consequently the time which the proboscis took to develope was only that which intervened between the emigration of a member of the genus to the New World and the evolution of the first species belonging to the modified type. Hence the time of transmutation is even shorter than at first appeared probable. The interesting beetle which gave rise to the discussion is well figured here.

**Structure and Hatching of Egg-capsules, &c., in Mantis.**‡—The capsules consist essentially of a series of stories, placed one above the other; in the centre of each story, C. Brogniart explains, is a chamber which is divided by a vertical partition into two and contains the eggs; it communicates with the exterior by a tube, leading to the front, whose lips form imbricated scales; the spaces surrounding this chamber are empty. The eggs are so arranged that the heads of the

* Kosmos, viii. (1881) pp. 57–61 (4 figs.).
† See this Journal, iii. (1881) p. 239.
‡ Comptes Rendus, xciii. (1881) pp. 94–6.

larvæ shall be directed forward and be in mutual apposition; each division contains twelve, each story, twenty-four; every egg is enveloped in a glutinous recess. The capsule itself is impermeable to water. The ootheca is built up of a foamy liquid which is spread out by the aid of the ends of the elytra; the abdomen works it up by regular movements and lays it on layer by layer, assisted by the cerci; the ova are expelled by the abdomen, accompanied by a certain amount of frothy fluid which forms the alveoli in which they are to lie.

The uselessness of the legs at the time of the emergence of the larvæ is compensated for, as observed by M. de Saussure, by backwardly-directed spines which, owing to movements of the body, push the insect forward, in the same way as an ear of rye may be made to travel over cloth, but the spines are placed in the cerci, not on the abdomen; the legs also are covered with strong spines. The uppermost eggs are the first hatched. Death sometimes occurs from the closing of the operculum over the opening before the larva is quite out. The retention of the larvæ by their cerci and abdomen on the surface of the capsule for some days after extrusion is a remarkable feature of the process; they are only released by the shedding of the skin in which they emerged, and which is left attached to the capsule; they are now very active and devour small insects greedily. The silky threads which they bear do not represent the cerci, as has been supposed; they appear to be used in facilitating the first moult by securing the larvæ to surrounding objects.

### γ. Arachnida.

**Observations on Acarida.***—P. Kramer first deals with the mode of reproduction in *Dermaleichus stylifer;* when a pair are found in copula, it is seen that the male takes such a position that the penis must needs be, as it is, longer than the abdominal appendages of the female. In dealing with the development of *Cheyletus eruditus* he points out that in it, as in the Spiders, there is a true care for the developing ova; if an attempt is made to remove the eggs the female attempts to seize the instrument with its palpi. Development commences by a cleavage of the yolk, which is gradually overgrown by a homogeneous blastema; and the anterior pole becomes distinguished by an aggregation of the yolk material. On the whole, the method of development calls to mind Claparède's account of *Myobia musculi*, where that investigator found that a deutovum and a tritovum were formed.

After a comparison of the genera *Sepis* and *Zercon* with *Gamasus*, the author proceeds to a description of *Scirus taurus* n. sp., and of *Glyciphagus ornatus*, n. sp. In the genus *Bdella* the following new species are described: *B. crassirostris*, *B. longirostris*, *B. lapidaria*, *B. arenaria*, *B. silvatica*, and *B. capillata*. The note concludes with some observations on the systematic characters of the sub-family *Eupodidæ*, and of its genera *Scyphius* and *Eupodes*.

* Zeitschr. f. Ges. Naturw., liv. (1881) pp. 417-52 (2 pls.).

**Pycnogonida of the 'Challenger' Expedition.**—Dr. P. P. Hoek's report lately published extends over 150 pp., and is illustrated by twenty-one plates. An interesting general account of a Pycnogonid is prefixed to the catalogue of the species at present known, in which indications are given of the habitat and range of each species. This is followed by descriptions of the forty-one species collected by the 'Challenger,' thirty-three of which are new; of the nine genera three are new. Those genera which range most widely geographically are also those which range most widely in depth. In an appendix the author gives a valuable sketch of the anatomy and embryology of the Pycnogonida, an account of which is deferred.

### δ. Crustacea.

**Hairs of the Anterior Antennæ of Crustacea.***—S. Jourdain, after a few words on the auditory hairs of this group, proceeds to point out the arrangement and structure of the processes found on these antennules, which were regarded by Leydig as having an olfactory function. Before describing the arrangements which obtain in the representatives of different orders, he says, that in all cases we find a very delicate chitinous sheath, which is penetrated by an offshoot from the hypodermic layer, and which, at its base, is found to be in relation with a branch of the antennary nerve; the free end is truncated and carries a hyaline body, which appears to be comparable to the rods found at the sensory ends of sensory organs. These may be known as the "poils à bâtonnet." The hairs are cylindrical in some cases, and then the chitinous cylindrical sheath is made up of a number of joints; the basal ones have thicker walls, and are shorter than those which are more distal. In other cases the hairs are *stipitate*, and then the joints are ordinarily reduced to three, and the basal one, which is of some length, is constricted in its middle.

A detailed study shows that the former arrangement is confined to the Podophthalmate Crustacea; the hairs are found in the young, though in less number than in the adult; and, similarly, they are more numerous in the higher than in the lower forms. Although there seems to be no doubt that these organs respond to stimuli which are something else than tactile, we are not yet in a position to definitely assert that they have an olfactory function. The author concludes by remarking that the characters of these parts have a value for the systematist.

**Nervous System and Sense-organs of Sphæroma serratum.**†—G. Bellonci describes firstly the different divisions of the brain of this Isopod; the third segment includes the two lateral œsophageal ganglia at the sides, and below, united by the œsophageal commissure, the four sub-œsophageal ganglia concentrated into a single one; also the seven thoracic connected by the longitudinal commissure, and the seven abdominal ganglia. Among the various nerves which are described as proceeding from this region, he notices specially the

* Journ. Anat. et Phys. (Robin) xvii. (1881) pp. 402–18 (2 pls.).
† Atti Accad. Lincei Rom., v. (Transunti), 1881, p. 228.

external pair of pharyngeals; they traverse a pair of small pharyngeal ganglia, as observed by Sars in *Porcellio*.

He also considers the structure of the central organs and the sense-organs. The medullary substance of the former, termed by him granular-reticulate substance, and described by Leydig, Dietl, and Krieger as a nervous reticulum, is considered to be made up of a nervous reticulum combined with connective tissue. The reticulation consists of fibrils derived from the peripheral nerves and from the central nerve-cells. The large nerve-cells have two processes which come from the same pole; one forms a nerve-fibre directly, the other merges in the reticulum. The small nerve-cells have each a single process, which breaks up in the reticulum. These ganglion-cells, which occur at the point of issue of the nerves, are bipolar. After describing minutely the structure of the brain, the author proceeds to determine the analogy which the cerebral lobes bear to those of insects. In speaking of the sense-organs, he alludes to the "rhabdum" (bacillar layer) and the "retinula." The compound eye consists of the dioptric part, composed of a biconvex corneal lens and a crystalline cone, and the nervous part, excluding the fasciculate optic nerve, which is usually full of nerve-cells. In the nervous parts may be distinguished, according to Grenacher, the retinula and "rhabdum"; the former is made up of five long cells, coloured black by pigment, alternating with the radii of the rhabdum, and proceeding from the fibres of the optic nerve. He admits, with Grenacher, that the rhabdum is a cuticular production of the cells of the retina. The problem of the homology between the retina of the Arthropods and that of Vertebrata is as yet insoluble, for the relations of the rods and cones to the other elements and to the nerve-fibres in the former group are not as yet understood.

## Vermes.

**Organization of Terrestrial Lumbricina.***—Prof. E. Perrier here deals with the genus *Pontodrilus*, two species of which, *P. littoralis* Grube, and *P. Marionis* n. sp., are found in France; the latter inhabiting debris wetted by salt water, has for three years lived in mud, &c., watered with fresh water. The forms of this genus are distinguished from *Lumbrici* by the postclitellar position of their generative orifices.

One of the most important chapters is that which deals with the segmental organs; they are not found in their normal condition until the fifteenth segment is reached, so that they are absent from the segments in which are contained the testicles, ovaries, oviducts, or anterior half of the efferent canals. As, however, they coexist in four rings with these last, and where the "prostatic gland" is developed, it is obvious that this gland is not a modified segmental organ. The first four segmental organs differ in structure from the rest; they are formed by a coiled glandular tube, which is ciliated internally, and opens by a narrower piece into the preceding segment. From the nineteenth segment backwards the glandular and vibratile portions are

* Arch. Zool. Expér. et Gén., ix. (1881) pp. 175–249 (6 pls.).

more independent of one another; the gland is much larger, and occupies nearly the whole of the space between the digestive tube and the walls of the body; the tube being bent on itself, gives rise to the appearance of two tubes imbedded in the gland, when this is cut through. The addition of a little chromic acid reveals the ciliated funnel. After a careful consideration of all the facts, Prof. Perrier comes to the conclusion that in many Oligochæta and perhaps in all, in the Hirudineæ, the Mollusca, and the Vertebrata, the vibratile infundibula of the segmental organs are always altogether independent of the generative apparatus, and form an integral part of the excretory system. It is true that in the Brachiopoda and the Gephyrea undoubted segmental organs take part in the service of the genital organs; but it is the entire organ which forms the duct, and not the infundibulum only; in other words, the author does not agree with the theory of Cosmovici.

The testicles are placed in the eleventh and twelfth segments, and the ovaries in the thirteenth. The former are large whitish glands, occupying nearly the whole of the segment, when mature. The author cannot accept the view of Ray Lankester that there are two pairs of segmental organs typically in each segment, one of which may become modified to form a part of the generative apparatus.

The circulatory system does not possess the sub-neural vessel, which appears to be found in all other terricolous Oligochæta; the system is very complicated in the anterior end of the body, where there are no less than five longitudinal vessels; the intestinal hearts have a double communication with the two dorsal vessels, an arrangement which, though not peculiar to *Pontodrilus*, seems only to be found also in a new species of *Titanus—T. forguesi.*

The dorsal pores, by means of which the body-cavity of *Lumbricus* is put into communication with the exterior, seem to be wanting in *Pontodrilus*, as in *Urochæta;* the most striking peculiarities in the enteric canal are the absence of the muscular gizzard, and of the typhlosole, the place of which seems to be occupied by a dorso-intestinal vessel.

In these last two points, as in the absence of the sub-neural vessel, the position of the male generative orifices, the simplicity of its locomotor setæ, as well as in the relative complexity of the vascular apparatus, and the small size and mode of development of its ova, *Pontodrilus* resembles the Naidina; in others, however, it is just as clearly a terricolous Lumbricid, and it conclusively shows that too great a distinction has been made between these two divisions of the Oligochæta.

**Action of Worms in the Formation of Vegetable Mould.***— Mr. Darwin here details the results of a series of observations on the share which earthworms have taken in the formation of the layer of vegetable mould which covers the whole surface of the land in every moderately humid country, prefaced by an account of their structure and habits.

* Darwin, C., 'The Formation of Vegetable Mould through the Action of Worms, with Observations on their Habits.' 326 pp. (15 figs.) (8vo, London, 1881.)

Mr. Darwin shows that what is generally called "vegetable" mould is almost solely the work of worms, and is, therefore, more animal than vegetable. They are constantly swallowing earth and small stones, and passing them through their bodies to the surface in a finely triturated and fertilized condition; so they may be said to manure the earth inside their own bodies. By means of this process the entire earthy surface of a country is constantly in a state of change; probably, all over, there are in every acre of land from 35,000 to 50,000 worms, and with so many at work, it is not difficult to imagine what will be the effect of a constant accumulation of their casts. In some cases, if spread over the ground, they would measure one-fifth of an inch in depth per year, equal to one inch of earth brought up from below, passed through the bodies of worms, and deposited on the surface in five years. In one instance 12 oz. of castings were thrown up in a year on a square foot, or 6·75 lbs. on the square yard, equal to $14\frac{1}{2}$ tons of so-called fertile "vegetable" mould over an acre in one year. Leaves and stones and lime and other substances spread over a field, and left untouched, have been found in a very few years several inches below the surface in a uniform layer. This, there can be no doubt, from the data supplied by Mr. Darwin, is all the work of worms. The millions of leaves and other vegetable matter dragged by the creatures underneath the soil, whether passed through their bodies or not, form a natural manure. Not only so, but "the bones of dead animals, the harder parts of insects, the shells of land molluscs, are before long all buried beneath the accumulated castings of worms, and are thus brought in a more or less decayed state within reach of the roots of plants." They are also a powerful factor in geology, performing a great part in the disintegration of rocks, not simply by direct action on the softer kinds, but by the indirect action of the acids which are mingled in their bodies with whatever they swallow, and which will have a slow but ultimately powerful effect on even hard rocks.

Mr. Darwin also shows that there is the greatest probability that whole towns, like the old Roman towns of Silchester and Uriconium, owe their preservation for the inspection of modern archæologists to a large extent to the ceaseless work of generations of these creatures, showing the great effects of a continually recurring cause, even when it seems almost infinitesimally small.

As to the powers of special sense, Mr. Darwin confirms the observations of Hoffmeister that worms, although without eyes, are sensitive to light. They are totally deaf to aerial vibrations, while very sensitive to the vibration of any solid object with which they may be in contact. Experiment also showed that the sense of smell is confined to the perception of certain odours, viz. to those emitted by natural food; and the presence of taste was proved by the preference shown for some kinds of cabbage over others. Of all their senses, however, that of touch, including in the term the perception of vibration, seems much the most highly developed.

Experiments on the intelligence of the worms were made by observing the mode in which they dragged leaves and triangles of

paper into their burrows; and it was found that in the case of leaves, that part of the leaf was, in the great majority of cases, seized by which the leaf would present the least resistance. Nearly three times as many of the triangles were drawn in by the apex as by the base.

**Prefecundation in Spio.***—A. Giard has observed that in the *Spio crenaticornis* of Montagu the mature ovum has the form of a spheroid, considerably flattened at its two poles; around the equator there are about twenty transparent vesicles connected with the vitelline membrane; their function would appear to be that of micropyles, and the author can only compare them with the follicular elements of the Ascidians. The germinal vesicle is very large and the always central nucleolus is likewise voluminous. Some time before the maturation of the ovum we may see in the germinal vesicle, at some distance from the nucleolus, a smaller cellular body; this eccentric element is nucleated; it approaches and gradually becomes applied to the nucleolus, when it loses its own nucleus and becomes at last reduced to a double membrane surrounding the nucleolus of the egg, with which it finally so fuses that no sign of this phenomenon is left in the egg. Nothing is known as to how this element penetrates, and the significance of the phenomenon still remains to be explained by further and wider observations.

**Northern Gephyrea.**†—In this magnificent addition to the literature of the Northern Seas, D. C. Danielssen and J. Koren give in Norwegian and English (in parallel columns) a full account of the results of their studies on a group to which in this year so much attention has been directed. The ten genera and sixteen species (of some of which, unfortunately, only a single specimen was obtained) comprise two new families, four new genera and seven new species, some of which are of the greatest significance.

*Phascolosoma lilljeborgi* n. sp., has a proboscis which is equal in length to the trunk, and is studded with minute pointed papillæ. *Aspidosiphon armatum* n. sp., has the surface of its body provided with chitinous plates, varying in size and arranged round the apertures of the glands of the skin. There are a number of chitinous hooks on the proboscis. *Onchnesoma glaciale* has a proboscis which is twice as long as the trunk, and the chitinous hooks are confined to its anterior fourth. The skin is hyaline. *Stephanostoma hanseni* n. g. et sp., has an oral disk which is exceedingly broad and carries, in addition to a few scattered tentacles, one large group of tentacular organs; the body is cylindrical, and the proboscis and trunk are about equal in length. The anal orifice lies close to the base of the proboscis. A new genus (*Hamingia*) is added to the family Bonellidæ (*H. arctica* n. sp.), from the other two genera of which it differs, however, in the absence of bristles and of a proboscis. In consequence of the absence of this latter organ the circulatory and nervous systems are somewhat modified; at the anterior extremity of the perivisceral cavity there is a floating muscular organ which appears to have the function of a

* Comptes Rendus, xciii. (1881) pp. 600–2.

† 'Den Norske Nordhavs Expedition,' iii. (1881) 60 pp. (6 pls. and 1 map).

heart, and is connected with the ventral vessel. The heart of *Bonellia* (Lacaze-Duthiers) is a sac-like expansion of the ventral vessel and is found about the middle of the cavity; at this point there is in *Hamingia* a vascular plexus uniting the dorsal and ventral vessels. The nervous system, again, has the pharyngeal ring more typically arranged than in *Bonellia.* Unlike this form the new genus presents a bisymmetrical arrangement of the uteri. *Saccosoma vitreum* n. g. et sp. is also an asetous form, which, while it differs in some important points from the other Bonellidæ, is personally most remarkable on account of the extreme tenuity of its intestinal walls; these form merely a "gauzy pellicle," and are so difficult to detect that, for long the authors were in doubt as to whether there was any intestine at all, "conceiving the whole posterior portion of the animal to constitute a receptacle for the fæces." The authors seem to be in great doubt as to whether this form should not be the type of a new family, but unfortunately a single specimen only was found. The only new family here defined is that of the Epithetosomatidæ (*Epithetosoma norvegicum* n. g. et sp.). Just behind the base of the proboscis this creature has a cleft or fissure, the bottom of which appears to be pierced with a number of minute apertures; on the inner surface of the skin, and extending along either side of the anterior end of the body and inside the fissure is a row of rounded apertures (four on each side); a kind of sphincter is formed around the orifices which lead to the bottom of the fissure; at the last point we find a kind of respiratory apparatus, through which the sea water is enabled to communicate with the perivisceral cavity, "for the labia of the fissure can evidently expand and contract for the admission and expulsion of the circulating fluid." Only two specimens, both in a bad state of preservation, were obtained, and the authors' account of some of the other organs is consequently imperfect. The presence of the respiratory apparatus just described is, however, a sufficient reason for the establishment of a new family, as it is an arrangement to which there is nothing analogous in other Gephyrea.

The authors conclude by remarking that, in their opinion, the present arrangement of the Gephyrea into the two orders *G. inermia* and *G. armata* is hardly satisfactory; three genera, here described, are without setæ, but they are nevertheless, on account of their anatomical structure, referred to the armed order; whereas, if the systematic classification had been strictly followed, they would have been placed among forms with which they have comparatively little in common.

**Hamingia glacialis.***—In describing this new asetal Echiurid, Dr. R. Horst points out that the homologue of the secondary gut, first noticed by Spengel in *Echiurus*, is represented by a canal developed from the wall of the exterior, and connected posteriorly with the hinder portion of the intestine. Like Lankester,† the author is unable to accept Greef's account of the structure and function of the anal tubes.

* Zool. Anzeig., iv. (1881) pp. 448–50.
† See this Journal, *ante*, p. 738.

**Anatomy of Sipunculus nudus.***—Dr. J. Andreæ publishes a preliminary notice of his studies from which we learn that the tegumentary glands are either bi-cellular or multi-cellular; in either case they are invested in a delicate membrane and open to the exterior by a more or less long efferent duct. In the first the two contained gland-cells are hemispherical in form, having their flat sides applied to one another; in the centre of the whole gland there is, however, a wide cavity between the two which is continuous with the efferent canal. In the multicellular glands, on the other hand, the cavity within the gland-envelope is traversed by a fine fibrous network, in the meshes of which are to be found elongated pyriform cells, and these, unlike the cells of the other form, are distinctly nucleated. Terminal sensory organs are irregularly scattered over the whole surface of the body, and consist of a large number of modified hypodermal cells, set in palisade fashion; in addition to these there are glandular organs which are connected with nerves. The histological elements of the musculature are fine elongated spindle-shaped fibres in which a thin hyaline sarcolemma, a delicately fibrillated mass, and a granular cord running in the axis of the fibre are to be made out. The musculature is closely connected with the true integument, along the lines of the longitudinal muscles; between these the skin is free, and so we have formed the tegumentary cavities. When subjected to microscopical examination the ventral cord was found to have a double investment of layers of connective tissue, which were separated from one another by a pretty considerable space; this last is not, as has been often supposed, a blood-vessel, but it is an essential part of the cord, and is filled up by a finely granular mass, in which are imbedded well-marked nuclei and a number of pigment-spheres.

**Development of Tricuspidaria nodulosa.**†—P. Mégnin here gives a somewhat fuller account of his researches.‡ In speaking of its migration from one part to another of its host, he states that it frequently seems to lose its way and to fall into the peritoneal cavity, when it will perish unless saved by the tooth of a carnivore more powerful than its host. These peritoneal Triœnophora, which lose their tricuspid spines, are the *Ligula nodosa* of the earlier helminthologists, and, in their asexual condition, the embryo, according to Bertolus, of *Bothriocephalus latus*.

The adult seems to attain the length of 10–15 cm., with a breadth of 0·5 to 4 mm.; the tail end is often discoid in shape.

**Development of the Trematoda.**§—We have here a notice of Prof. G. B. Ercolani's work on this subject, illustrating the process of the adaptation of an individual to the surrounding medium. The subjects of study were the important forms *Distomum hepaticum* and *D. lanceolatum*; and the author shows that the same *Cercaria* or embryo, if developed in two different media or animals, alters its specific

* Zool. Anzeig., iv. (1881) pp. 477–81.
† Journ. Anat. et Physiol. (Robin), xvii. (1881) pp. 419–26 (1 pl.).
‡ See this Journal, *ante*, p. 604.
§ Journ. Anat. et Physiol. (Robin), xvii. (1881) pp. 434–6.

characters and takes on a form adapted to its medium; the hosts experimented on were *Rana temporaria* and *Tropidonotus natrix.* M. Ercolani finds, as has Mr. A. P. Thomas, that the ova do not undergo any development during the cold of winter.

**Distomum of the Crayfish.***—Prof. G. Zaddach reports that several years ago he found a number of cysts of *Distomum cirrigerum* in crayfishes; his attention was first directed to them by the peculiar characters of their testes on which he saw blackish spots; they were afterwards observed in greater number in the muscles of the post-abdomen, where they ordinarily lay near the surface. Notwithstanding their presence the infested crayfishes were found to be perfectly healthy, and the author points out that the evil effects of trichinosis are only effected when the parasite wanders, and so sets up nerve-irritation; the migrations of the Cercariæ, on the other hand, seem in no way to affect the health of their hosts; and the same is generally true of the other Trematode parasite, *D. isostomum.* The author enters into a detailed examination of the characters and habits of these forms, and comes to the somewhat remarkable conclusion that in *D. isostomum* two sexually mature forms succeed one another.

**Urinary Apparatus and Blood-lymph Spaces of the Platodes.**†—Prof. E. Van Beneden points out that the results of Fraipont's investigations lead to the demonstration of a system of spaces, which is independent of the canalicular system of Ray Lankester, and which was unknown to that naturalist; from this it follows that the canalicular system must not be regarded as a cœlom as well as the urinary apparatus, but as the latter of these only.

**New Rotifers.**—Mr. H. F. Atwood describes and figures‡ a *Brachionus* which he considers to be new. It was found in a filtering of Hemlock Lake water, and the name of *B. Conium* is proposed for it:—

"Lorica irregularly truncate, slightly reticulated over entire surface, except the collar carrying frontal spines; this latter portion has a hard vitreous appearance.

"Ten frontal spines, the middle one on the dorsal surface longer than the balance, and describing almost a right angle turn near its centre to one side. This spine half as long as the carapace of the rotifer; eye-spot prominent; no openings on dorsal surface of carapace.

"Four posterior spines, one at either extreme side, and one on either side of anal opening. Tail, or foot, slender and bifid. Extreme length of rotifer, including anterior and posterior spines, $\frac{7}{1000}$ of an inch."

Unfortunately a dead specimen had to be used for the drawing, hence no definite description can be given of mouth-parts for internal structure. The external appearance is, however, so strikingly charac-

* Zool. Anzeig., iv. (1881) pp. 398–404, 426–31.
† Ibid., pp. 455–9.
‡ Science, ii. (1881) p. 235 (2 figs.).

teristic as to serve all purposes of identification until the internal structure can be fully described.

Mr. F. W. Phillips also records * and figures a species of *Brachionus* which he believes to be either a variety or an undescribed species. It most resembles *B. Bakeri*, but differs in the arrangement of the granules and the position and shape of the spines. It was found at Hertford Heath, and in such vast numbers as to render the water turbid.

Observations on Rotifera (Melicerta).†—The following observations were made by M. L. Joliet on *Melicerta ringens* and an allied species which is distinguished by the presence of a long thread that fixes it in its case. Save in some details, the remarks concerning one are applicable to the other.

*Nervous System.*—Several authors have followed Huxley in the statement that the ganglion of *Melicerta* is situated near the mouth, and consequently on the opposite side of the body to the anus. This would be the converse of what exists in all rotifers. In reality what these observers have taken for a ganglion is a gland, both in its structure, situation, and functions. The true nervous centre is on the opposite side, on the dorsal face of the pharynx. It is composed of a group of large, characteristically formed cells, with a large nucleus. Several similar cells are disposed on the sides of the former and spread in different directions. This centre somewhat resembles that described by Leydig in *Lacinularia*. It is not large, and M. Joliet thinks that in many rotifers the relatively enormous ganglia that have been described are glands, and that the true nervous centre has yet to be found. In any case the anomaly thus created for *Melicerta* does not in fact exist.

*Reproduction.*—During the whole of the summer three kinds of eggs are found in the tubes which the animals inhabit: the male summer-eggs, which are the smallest and which have not been noticed; the female summer-eggs, which are larger; and the yet larger winter-eggs, extremely opaque when laid, and later on becoming encysted in an ornamented chitinous membrane within the first chorion. These different eggs are not laid by all the females indiscriminately, but each one has, so to say, its speciality.

*Formation of the Egg.*—All the eggs in the ovary have a uniform aspect and appear equally developed, with the exception of a single one which, detached from the ovary and placed in that portion of the enveloping membrane that may be termed the maturation pouch, is always extremely granular and enlarges with such rapidity that in less than twenty-four hours it attains a volume more than fifty times greater than that which it had preserved for several weeks in the ovary. This is explained by the fact that the stroma of the genital gland perpetually secretes a large quantity of granules of deutoplasm. These granules the free egg agglutinates with rapidity and mixes with its own vitelline substance. In certain *Floscularicæ*, in

* Trans. Hertfordshire Nat. Hist. Soc., i. (1881) p. 118 (1 fig. of a pl.).
† Comptes Rendus, xciii. (1881) pp. 748–50.

which the maturation pouch is wanting, and where the detached egg falls into the general cavity, these granules are seen to circulate and spread everywhere in the body, even in the limb and pedicel, finally uniting with the egg, which also grows rapidly. In these facts the author sees a sketch of what happens in many Turbellarians and in the Trematoda.

*Winter-egg.*—The much-discussed winter-egg is regarded by Huxley not as a true egg, but as a portion of the ovary separated from the rest; a sort of composite of several eggs. He does not admit that these eggs undergo segmentation after laying. M. Joliet is able to affirm that the winter-eggs are formed in *Melicerta* exactly in the same way as summer-eggs, and, like them, segment after deposition. What has probably deceived the eminent observer is the fact that the vitelline granules of the winter-egg, being extremely opaque, darken very much the stroma of the ovary which secretes them. The first phases of segmentation are identical in both cases; it is difficult to follow the transformations in all their details, owing to their extreme opacity, but the general progress is exactly the same. As the development advances, the egg becomes lighter in hue till it takes a citron tint which it retains throughout the winter. It is then covered by an internal ornamented shell and formed of "parchment cells." At the end of winter, as a rule, this latter shell alone remains, and towards March or April there issues from it a small, but perfectly formed *Melicerta* which does not pass through the phase of a ciliated and swimming larvæ, as does that from a summer-egg.

*Male Summer-egg.*—This has a similar development to that of the female summer-egg, at least as far as the closing of the blastopore. The animal which issues from it is about half as small as the female larva, which it resembles in its general form, but it differs from it in the complete absence of the digestive tube, and in the presence of an organ which, by analogy with the male of *Lacinularia*, the author considers to be a sperm sac, though as yet he has not discovered any spermatozoid in it, but at most mother-cells. This may be because he has always observed the male shortly after it has hatched out, and has not made any observations on its rôle. It is rare, dies speedily, and has never been seen in any tube of a female. Whether it fecundates all the females, or only those from winter-eggs, or whether the reproduction is exclusively parthenogenetic, the author is not able to decide. Nor has he been able to observe in any female anything resembling a spermatozoid.

The egg from the maturation pouch is covered with a thick chorion: it always commences to segment immediately after laying, and apparently under the action of the water, for the egg ready to be laid which remains in a dead female, does not segment, but perishes, unless the chitinous envelope of the mother is torn so as to admit the water, in which case the egg soon commences to develope.

### Echinodermata.

**Echinoidea of the 'Challenger' Expedition.**—The full report of Prof. A. Agassiz has now been published, extending over 300 pp.,

and illustrated by 45 plates. The author discusses in some detail the question of the determination of the "axis" of the Echinoidea, and compares the coronal plates of the test. After a chapter on acanthology, the author insists on the hopeless nature of the attempt to represent the direct succession, either diagrammatically or descriptively, of the Echinids of the present epoch from those of the chalk. The Jurassic, cretaceous, and tertiary Echinoids are considered in relation to the present Echinid fauna; and from this the work passes to the more strictly descriptive portion, to conclude with systematic tables, which contain an account of the horizontal and vertical distribution of the Echinoidea.

**Morphology of the Sur-Anal Plate.***—In describing a case of the apparent retention of this plate by a young *Echinometra*, Prof. Jeffrey Bell takes occasion to raise the question whether this plate has "of itself or primarily, any relations to the covering plates of the anal area"; in the present specimen no such relations are to be seen, and in it, just as in *Salenia*, there is no question as to the small anal plates being distinct from the sur-anal. It is now generally supposed that the sur-anal plate and the large plate found among the covering plates of the anal area of some forms, are homologous, but the author points out that this latter lies within the boundary of the anal area, and he concludes that so far as morphological identity can be spoken to by similarity in position, this homology must be something more than doubtful; the large anal plate of the Temnopleuridæ has probably been secondarily acquired.

**Comatulæ of the Leyden Museum.**†—Mr. P. H. Carpenter has been able to do good service to the students of this group by the publication of these notes, as the Leyden Museum contains the types of six of the species described by J. Müller; a key is given to the species here described, the old forms being fully commented on, as well as eleven new species described. These are *Antedon perspinosa*, *pinniformis*, *serripinna*, *bimaculata*, *brevicuneata*, *lævicirra*, and *spicata*; *Actinometra robustipinna*, *alternans*, *schlegeli*, and *peronii*. Nearly all these forms are from the Eastern seas. A discussion of the characters of the *Phanogenia typica* of Lovén is entered into, and that, for a time, difficult form is now placed in the genus *Actinometra*.

## Cœlenterata.

**Shortened Development in the Discomedusæ.**‡—Professor E. Haeckel has lately had a very favourable opportunity of studying that well-known member of this group, *Aurelia aurita*, having kept a number of specimens in his aquarium. He has observed certain phenomena in the mode of reproduction which deviate from those which usually occur. The normal process of reproduction is that which prevails in the group generally, viz. by ovum, gastrula, Scyphistoma, metamerically segmented or Strobila-stage, culminating

* Journ. Linn. Soc. (Zool.), xv. (1881) pp. 318–20.
† Notes from the Leyden Museum, iii. (1881) pp. 173–217.
‡ 'Metagenesis und Hypogenesis von *Aurelia aurita*.' Jena, 1881, 4to (2 pls.).

in the adult Medusa. Instead of the ordinary method—*metagenesis*, or alternation of generations—direct methods of development, termed by the author *hypogenesis*, may take place, by arrest of metamorphosis at different stages.

Of mere varieties in the development the following are the chief:—Firstly, the gastrula may cease development before the primitive planula cavity is obliterated by complete invagination of the entodermal cells into the ectoderm; the remains of the planular cavity become the disk of a Medusa, while tentacles spring from the lips of the gastrula mouth. Secondly, larvæ of the Scyphistoma-stage may develope several circles of tentacles, forming a strobiloid growth, in which, however, the rings or metameræ preserve their polype-like character, and do not take on that of Medusæ (*Ephyrulæ*), as in the true Strobila; or the tentacles may branch, each giving off two or three branches, or this branching may be confined to the eight principal (viz. the four primary and four secondary) tentacles, which each thus become triple. Thirdly, in the Strobila-stage the ordinary production of from ten to twenty medusoid heads, or "Ephyrulæ," is very frequently reduced to that of one such head, for the support of which the basal segment sometimes becomes merely a pedicel. Fourthly, the "Ephyrula" or free, freshly-budded stage of the Medusa, may either develope divided lobes and sense-bulbs only on the four primary marginal lobes of the disk, the secondary lobes bearing only trifurcate tentacles (a variety termed *Ephyrula connectens*), or (*E. sphinx*), the anterior, i. e. mouth-part, may have the typical Medusa characters, while the hinder part has the body of the Scyphistoma-polype persisting—a condition which may be carried so far as to make the larva a sessile Medusa, as in *E. pedunculata*, or a sessile polypoid Medusa, termed *E. tesseroides*. The hypogenesis or direct development is effected by the arrest, as in the first-mentioned variety, of development at the gastrula-stage, the contents of the planular cavity becoming the gelatinous disk-tissue; the mouth of the gastrula broadens, the body flattens; a groove developes round the mouth, and becomes the cavity of the umbrella; from the edge outside it, tentacular and ocular lobes sprout out. The edges of the mouth grow downwards, the convex body flattens; the result is an Ephyrula-disk, which thus dispenses with the Scyphistoma- and Strobila-stages. It remains still to be seen whether these apparently startling variations, produced, as they avowedly are, under the operation of artificial conditions, occur with any frequency in the natural state of things; and further, whether the author's deductions as to the morphology of the normally developed parts, made from such varietal phenomena, can be considered to possess the value of absolute fact.

"**Mouth-arms" of the Rhizostomidæ.***—O. Hamann, attracted by the question of whether these appendages are developed from the gastric filaments (which would ascribe to them an endodermal origin), or whether they are ectodermal in origin, has been

* Jenaisch. Zeitschr. f. Naturwiss., xv. (1881) pp. 243–85 (3 pls.).

carefully investigating their structure and history. The character of the stomatodendra is still almost unknown; it is still believed by many that they have the function of suckers, a view which is not supported by the facts.

In *Archirhiza primordialis*, the eight stomatodendra are unjointed and unbranched; and through them there passes a canal or vessel, the primary canal. On their axial side they are provided with suckers, which may henceforward be known as infundibular frills and their orifices as the infundibular orifices; each frill has always the shape of a funnel, and in each there is a canal, derived from a primary vessel of the arm. In *Cephea conifera* the primary canal divides into two secondary ones, which again give off smaller branches. In *Polyrhiza vesiculosa* the stomatodendra branch dichotomously, but the vascular system resembles that of the preceding form. In *Cassiopeia ornata*, the eight cylindrical arms break up into three or four pairs of primary branches, which again divide; here there is such an alteration in the vascular system that the canals are branched. After dealing with these forms of the Toreumidæ, the author passes to the Pilemidæ, where he finds a primary vessel with three subsidiary ones, which run parallel to it. In the Versuridæ the frills are confined to the ventral surface of the stomatodendra, and the vascular system is consequently simple. In the Crambessidæ there is a primary vessel in the upper arm, which, at the base of the pyramidal lower arm, divides into three subsidiary branches, which give vessels to the three rows of frills.

In discussing the origin and structure of the digitelli, or small tentacular organs which are found around the orifice of the infundibular frills, the author states that there is always found in them, just as in the gastric filaments, an axis of gelatinous substances, invested by a layer of ectodermal epithelio-muscular cells; the axis appears to be broken up by transverse constrictions into chorda-like cells, but this is a phenomenon which is only apparent after the death of the animal. They are to be distinguished (1) from the true tentacles by the fact that these, which primitively arise from the margin of the disk, have their axes hollow, or formed by endodermal cells, and (2) from the gastric filaments, which have their axes invested by endodermal epithelium.

In attempting to solve the problem of how the four mouth-arms of *Aurelia* (e. g.) became the eight stomatodendra of *Rhizostoma*, the author appeals to the *Aurosa furcata* of Haeckel, where the four arms are each divided by a notch into two diverging pieces; the canal appears, in development, to divide first, and he thinks that the form of the lobes is but a secondary process. After treating of some other parts connected with these organs, the author examines the question of the mode of nutrition; he finds that in hungry specimens the infundibular frills with their orifices are widely open. When an animal adapted for prey comes near the orifice, the frill, owing to its possession of epithelio-muscular cells, is able to extend itself, and by means of the digitelli to seize the creature. Within the frill, the captured animal is digested by the endodermal investment, and frills have been found containing the half-digested remains of Crustacea. The nutri-

ment is driven through the canals by means of the ciliated cells, aided by muscular contractions; the vessels are so extensile as to be able to take in fishes of some considerable size. The undigested parts—the skeleton of Crustacea, for example—are returned by the orifice through which they entered. We find, then, that the Rhizostomidæ differ so far from the other Medusæ that digestion does not take place in the stomach, but in the frills and canals. The function of the accessory urticating and other organs is then discussed, and it is found, as might be expected, that they give some aid in attacking the prey. The author insists in his *résumé* on the morphological fact that every series of frills has its own vessel.

### Porifera.

**Supposed Heteromorphic Zooids of Sponge.***—Professor E. P. Wright describes, as the representative of a new genus and species, a sponge from one of the Seychelles Islands which he names *Alemo seychellensis.* It is closely allied to the genus *Tethea* Schmidt, if, indeed, the possession of three distinct forms of stellate spicules, and of the apparently dimorphic bodies here called zooids, is sufficient to separate it from that genus. The heteromorphic zooids referred to are spiculose, pedicellate bodies, which are projected from the main mass of the sponge, at right angles to it. Two forms of these bodies are distinguished; the one is ovoid, almost smooth, and terminated by an osculum; the other is irregularly fan-shaped. These two kinds occur together in couples, and are interpreted as being two distinct forms of zooids. These remarkable formations appear, however, as surmised by the author, to be simply instances of that form of *gemmation* which is a far from uncommon occurrence in the genus *Tethea,* and which has been also observed in the kindred genus *Rinalda.* The dimorphism of the buds is an interesting fact which stands in need of further elucidation.

**Habits and Structure of Clione.**†—N. Nassonow finds that these boring sponges live on the shells of living oysters as well as on empty shells. They give off from the surface very delicate pseudopodia-like processes, which pass in all directions into the substance of the shell; these processes may branch, and even anastomose with one another. The author, by placing in the aquarium fine transparent lamellæ of oyster-shells, saw the young *Clione* push its processes into the calcareous lamellæ; when they had reached a certain depth they united with one another, and forced out hemispherical calcareous particles; these were by contraction carried into the interior of the body, and then cast to the exterior. The ectoderm is reported to consist of flat, colourless epithelial cells, with processes, by means of which the cells are connected together; the mesoderm is formed by a mass of layers of oval, yellow cells.

**Soft Parts of Euplectella aspergillum.**‡—In spite of its familiarity to naturalists and the world at large, no satisfactory account of

* Trans. Roy. Irish Acad., xxviii., pp. 13–20 (1 pl.).
† Zool. Anzeig., iv. (1881) pp. 459–60.
‡ Trans. Roy. Soc. Edinburgh, xxix. (1880) pp. 661–73 (1 pl.).

the soft parts of this beautiful and highly evolved form has hitherto appeared. Professor F. E. Schulze has now undertaken this task, having had at his disposal for the purpose the specially prepared specimens brought to England by the 'Challenger.' Of these specimens those preserved simply in absolute alcohol were alone available for satisfactory histological examination.

The soft tissues are pale yellowish-grey in colour, are small in quantity, and constitute a meshwork of fibres or membranes. The lateral walls are penetrated by numerous circular "wall-openings" about 2 mm. in diameter, arranged in spiral rows, and maintaining a constant communication between the interior of the sponge and the surrounding water. There are, besides, openings on the inner surface which lead into the body-wall and lie in the angular intervals of the skeleton, viz. (1) larger openings underlying the prominent outside ridges, either single or two or three in each interval; (2) smaller openings, underlying an outside boss, several in each such area; both sets are excretory in function. The wall is made up of—not considering the silicious elements—a *skin* which stretches between the radially directed main axes of the large six-rayed spicules to which the floricomo-hexradiates ("floricomes" of Schulze) are attached; this skin is pierced by the dermal pores, which are numerous and communicate with subdermal spaces, formed of a lacunar network. At the inner side of the latter is found a system of ciliated chambers; these are large cylindrical sacs, circular in transverse section, with a cœcal rounded termination, average dimensions $\frac{1}{10}$ by $\frac{3}{50}$ mm.; they lead by circular apertures into digitate excretory cæca, $\frac{1}{10}$ to $\frac{1}{5}$ mm. in diameter, which lead either into canals which open at once into the interior of the sponge at the large openings (1) above mentioned, or unite to form still larger canals with openings 3 mm. in diameter; the canals in those parts of the wall which lie between the large ridges are much shorter and open directly to the interior by the numerous small openings (2) above mentioned. There are no ciliated chambers in the tissue immediately surrounding the wall-openings. The regular external oscular openings are those of the cribriform plate, not the wall openings; the plate is thinly covered by soft matter containing ciliated chambers at its outer side. The root tuft of fibres appears to be quite destitute of soft tissues.

With regard to the *histology*, three body-layers are distinguishable; the ectoderm covers the external surface and lines the inhalent spaces; its constituent cells were not distinctly made out, but their existence is indicated by the presence of small round nuclei, regularly distributed. That part of the endoderm which lines the excretory canals and the general internal surface of the sponge closely resembles the ectoderm; that lining the ciliated chambers has a very different character, although the structure of the lining epithelium was not fully made out; but here the lining cells were observed as aggregated roundish masses, each containing a small round nucleus with strongly refractive nucleolus, like that usual in collar-cells of other sponges; no "collars" or cilia could be detected; the most remarkable point determined in the chambers was a reticulate arrange-

ment of the cells into meshes formed by decussating spiral or oblique rows, in which they are connected by stout refringent protoplasmic trabeculæ. The mesoderm is colourless but granular, and contains small oblong connective-tissue nuclei, and refractive balls of reserve nutritive material. Between the meshes of the ciliated chambers were found sperm-masses about $\frac{1}{20}$ mm. in diameter, the heads of the spermatozoa being distinctly visible.

Of interest is also the discovery within the inhalent passages of a new and remarkable commensal Hydroid, which Professor Schulze names *Amphibrachium euplectellæ;* it is a gymnoblastic form, and consists of branching colonies, enclosed in perisarcal tubes; its tentacles are knobbed, and only two in number.

**Spongiophaga in Fresh-water Sponges.***—Mr. H. J. Carter has established the existence of *Spongiophaga* in the fresh- as well as in the salt-water sponges, having identified a new species (*S. Pottsi*) on specimens of *Spongilla.* It is distinguished from the marine species in that the filament does not end in a bulb at each end, though it is in other respects identical.

**New Genera of Fresh-water Sponges.**†—Mr. E. Potts proposes to group under the genus *Heteromeyenia* two species which differ from the rest of those in Mr. Carter's genus of *Meyenia*,‡ in which he grouped those species in which the statoblast is surrounded by birotulate spicula, the shafts of which are of a nearly uniform length. In the two species above referred to, however, the uniform series is broken by another of about double their length, much fewer in number, somewhat regularly arranged, interspersed among them.

A second new genus is named *Carterella*, in which is placed *Spongilla tenosperma* § and *C. tubisperma* in which the tube is much longer than in any sponge heretofore described. Also the more recent discovery *C. latitenta.*||

## Protozoa.

**Biology of the Inferior Organisms.**¶—Dr. K. Roser has undertaken a series of experiments on the habituation of marine Infusoria to an existence in liquids containing salts, such as urine, milk, and blood; his conclusions relating to the adaptation of the pathogenous forms are worthy of notice. He makes use chiefly of *Polytoma uvella*, and finds that if a drop of urine is brought into contact with the living animal while under the Microscope, the cilia may be observed to suspend their movements, the cell-contents shrink up and away from the cell-wall, and the action is the same as that of drying, owing to removal of the water. Death does not, however, take place, for the addition of pure water revives the Flagellate,

* Ann. and Mag. Nat. Hist., viii. (1881) p. 222 and p. 354 (1 pl.).
† Proc. Acad. Nat. Sci. Phila., 1881, pp. 149–50.
‡ See this Journal, *ante*, p. 614.
§ Ibid., p. 613.
|| Proc. Acad. Nat. Sci. Phila., 1881, p. 176.
¶ Marburg, 1881, 30 pp. (1 pl.). Kosmos, ix. (1881) pp. 475–6.

which reproduces its species in water containing $\frac{1}{8}$th of urine better than in water devoid of salts. It can be reconciled to a strongly saline solution, so that in five weeks it multiplies with great rapidity in unmixed blood. The author ascribes the acquisition by Infusoria of the power of existing in the body to the habituation to the saline contents rather than, as Grawitz holds, to the alkaline principles there found.

Dr. Roser has also demonstrated to his own satisfaction that vegetable seeds (peas and beans) when placed in urine or hydrocele fluid swell up, but do not germinate; from this he concludes that the reason why seeds which penetrate into the air passages, the nostrils, or auditory meatus fail to germinate in spite of the favourable conditions of moisture, warmth, and carbonic acid which they meet with, is that they, or rather the plants which produced them, are not accustomed to the amount of salts contained in the blood. The leading principle laid down is that "no parasites or infectious fungi are able to gain a footing in the animal body, but such as have been previously adapted to the proportion of saline matter in the blood. A cell of necessity collapses when transferred from a medium which is poor in salts, such as good drinking water, directly into the serum of blood. Drinking water rich in salts is bad, i. e. likely to convey infection." If this is true, the first thing required for successful inoculation or infection with such organisms is that they shall not be found to assume, by abstraction of water, the dried-up condition on being transferred to a new medium containing salts.

**Infusoria Parasitic in Cephalopods.***—Alex. Foettinger found in the renal organs of *Sepia elegans* and *Octopus vulgaris* two Holotrichous Infusoria, for which he proposes the names of *Benedenia elegans* and *B. coronata*. In other Cephalopods which he examined he found no parasites but *Dicyema* in those organs. *B. elegans* is elongated and cylindrical, but enlarged at its anterior extremity; at the anterior end of the head there is sometimes seen an apparent solution of continuity which may perhaps be a cytostome. In length the creatures may attain to 1 mm.; their mode of movement is somewhat peculiar, for in addition to moving forwards they are rotated on their own axis; sometimes the body is folded at certain points, but the animal may move without these folds disappearing. These movements are due to the vibratile cilia which cover the whole of the body, or to muscular fibrillæ, which in the living state have an elongated S-shape, and give rise to the appearance of fine transverse striæ. The fibrils extend from the anterior to the posterior end, and form a spiral around the body. There is no sign of any digestive tube or anus; the vacuoles are not contractile, the nuclei are invisible during life and are only seen when the Infusorian is treated with colouring matters. In some cases there is a single ribbon-shaped nucleus which extends throughout the whole length of the body; sometimes there are a small number of ribbon-like bodies, which give

* Bull. Acad. R. Belg., l. (1881) pp. 887–95. Arch. de Biol. ii. (1881) pp. 345–78 (4 pls.).

off processes in all directions; in other cases the nuclear fragments are very numerous, and have the form of homogeneous granular rods or spheres. From these observations it may be concluded that the nucleus of *B. elegans* exhibits some peculiar characters; in the living state it is not a fixed and immobile element, but it is endowed with amœbiform powers, in virtue of which it gives off processes, and divides into fragments which take on a spherical form, and can no doubt fuse again to form a single body. The only mode of reproduction observed was that by transverse fission; a transverse groove separates without detaching a fragment of the hinder part of the body; this, which is not small, divides into two; each of these halves again divides, and the resulting pieces again dividing give rise to eight, which for a time remain attached to the hinder extremity of their parent; the segments appear to detach themselves separately, the hindermost doing so first. The author believes that the nuclei divide into fragments before the appearance of the process of segmentation, but exact observations on this point are still wanting.

*B. coronata* is distinguished by the marked development of the cilia at the anterior region, where they form a true crown; the nuclei vary greatly in form, but are not so large as in *B. elegans*. Here again there is segmentation. The author thinks that *Benedenia* is one of the family *Opalinida*.

In the liver of *Sepiola rondeletii*, M. Foettinger found an ovoid Infusorian without mouth or digestive tube, which he proposes to call *Opalinopsis sepiolæ*. In size about 0·1 mm., they exhibit a holotrichous arrangement of their cilia, and present, below their delicate cuticle, the same appearance of muscular fibrillæ as that which has been already noted in *B. elegans*. The author insists on the muscular character of these structures, basing his views on the facts that the fibrils diminish in thickness towards either pole of the animal, and that their dotted appearance calls to mind the muscular fibrils discovered by E. van Beneden in the Gregarinidæ; moreover, the appearance, the refrangibility, and the dimensions of these fibrils are brought forward as supporting this view. The nuclei may be either small granular spheres, scattered through the protoplasm, or they may fuse; at other times they are spherical or rod-shaped, and occupy in numbers the central part of the Infusorian. Sometimes they give rise to a still more interesting plexiform arrangement. The amœbiform character of the nucleus is here again noted, as is also the phenomenon of transverse division; conjugation also was sometimes observed.

*Opalinopsis octopi* is a very similar form which was found in the liver of *Octopus tetracirrhus*.

**Flagellata.***—J. Künstler claims to have established some new points in regard to the very minute anatomy of Flagellata. In *Cryptomonas ovata* there is in the superior portion a narrow cavity which extends from the dorsal to the ventral face and forms a kind of vestibule for the digestive tube. The two flagella are inserted at the centre of this cavity, at the base of a tube which projects from its

* Comptes Rendus, xciii. (1881) pp. 602–5.

interior; they exhibit a distinct transverse striation, and call to mind exactly a muscle-fibril. The author cites a number of forms in which he has observed a similar striation. In addition to these terminal locomotive organs there is a group of flagella, the presence of which does not seem to have been hitherto noticed; they are likewise striated, but appear to serve in the prehension of food. The walls of the body are made up of four layers, of which the outermost or cuticle is colourless, while the rest are impregnated with chlorophyll. In the deepest of these there are polygonal starch-grains, which when well developed are so closely appressed as to give almost a reticular appearance. They are so regularly arranged as to seem to be the signs of a real division of the formative layer into small protoplasmic spheres, each of which produces a starch-granule in its interior. In the two other tegumentary layers, which are less thick, there are a large number of extremely small vacuoles, filled with a watery protoplasm, and separated from one another by the delicate parts of the denser substance. An analogous structure is to be seen in the enveloping cuticle.

There is no œsophageal tube, as has been described, but a spacious and well-bounded stomach in which the food is digested; the thick walls of this organ present a number of granulations, regularly arranged; these are starch-granules. Where they are wanting it is possible to see that the constituent protoplasm has a regularly vacuolated structure, and that its irregular appearance is due to the presence of these granules. An intestine and anus are also described. The contractile vesicle is said to communicate with the exterior by a pore, to have distinct vacuolar walls, and to give off a short canal from its inferior portion.

The nucleus is reported to be regularly and finely vacuolar and to have a certain number of nucleoli; the vesicular corpuscles frequently divide transversely, and may be seen to be surrounded by a zone of clear protoplasm. These the author looks upon as germs. Above the stomach and to the front and right of the nucleus there is a large and finely vacuolated mass of protoplasm, in which there are a number of nucleolar corpuscles, and whence a tube passes to the vestibular duct. This is regarded as an excretory organ or a male apparatus, and the latter hypothesis is inclined to on the ground that some kind of copulation has been observed in this form.

For the purposes of studying the oculiform spot of the Flagellata the author selected *Phacus pleuronectes;* in individuals kept in comparative darkness the spot is feebly developed; when placed in a quantity of light the spot became large, brilliant, and very red; and the organ is reported to consist of a collection of red, irregularly pyriform granulations, the internal substance being hyaline; all the granules are placed on a curve, and the corresponding concavity contains a transparent, refractive, and lenticular corpuscle; so that from the structural point of view the author is satisfied as to the visual functions of this organ.

The author points out that the peculiar mode of division, which appears to be intermediate between fission and gemmation, is due to

the presence of a firm shell, and it offers yet another proof of how easily division may pass into gemmation. In *Acineta mystacina* he has observed that gemmation, fission, and the separation of small pieces may all be observed at the same time; this deviation from the mode of simple fission, which is the primitive and fundamental mode of reproduction among the *Protozoa*, is clearly due to the need of rapidly producing a large number of individuals; but it is just as clear that the sole mode of reproduction among the Thalamophora is a mode which follows the type of the division of the cell.

The statements of the author in regard to the striation of the flagella and similar points of minute anatomy must be received with great caution, to say the least.

**Structure of Trichodina steinii.***—F. Vejdovsky identifies the Infusorian described without name by Hallez in his recent work on the Turbellaria, p. 84, pl. v., figs. 22–5, with the species *Trichodina mitra*, and proceeds to rectify sundry errors in that author's description and some omissions in the account given by Claparède and Lachmann from the study of the species, *T. steinii*, described by those authors and found on *Planaria gonocephala*. The oral circlet of cilia runs round the anterior end of the body, beginning and ending in the mouth-opening; it is accompanied by a fine undulating membrane which lies at its inner side and in contraction serves to close in the mouth-opening. The organ of fixation is a hollow, funnel-shaped structure, possessing, in contrast to the complicated arrangement in *T. pediculus*, only a set of simple hooks on the outer side; the edge is lined by long, closely-set cilia, not by an undulatory membrane; the surface is invested by a strongly developed cuticle which shows distinct radiating striæ, extending to within a certain distance of the edge; the hooks are from twenty-two to twenty-four in number, probably chitinous, and attached proximally to the cuticle; they probably represent modified cilia. The body consists of granular protoplasm, containing many globules; of contractile vacuoles, a large one is always found in the centre of the body, but sometimes also a smaller one at the anterior end. The nucleus is horseshoe-shaped, long, and sometimes spirally twisted at the opposite free ends.

**Fission of Monothalamous Rhizopods.†**—Dr. A. Gruber, in continuation of his studies, finds that if we make a general review of this phenomenon we see (1) That in the naked Amœbæ and their allies, the division of the nucleus and of the protoplasm seem to go hand in hand; (2) In such forms as *Lieberkuhnia*, where the body is protected by a secreted membrane, this may be so soft as to exert no influence on the mode of division; (3) In *Gromia*, *Microgromia*, &c., the investment forms a firmer capsule, which can take no share in the reproductive act, and here the protoplasm is extended from the orifice, and is at first without any nucleus; (4) In more complex forms the thin membrane around the body becomes covered by particles of sand,

* SB. K. Böhm. Ges. Wissensch. (Prag) 1881, pp. 115–20 (1 pl.).
† Zeitschr. f. wiss. Zool., xxxvi. (1881) pp. 104–24 (2 pls.).

diatom-shells, &c.; this is seen in *Difflugia* and its allies, and here a portion of protoplasm is extended from the mouth of the shell, and remains in connection with the mother until it has become nucleated and got its investment. For this purpose the parent cell has previously collected the material, so that the daughter-cell rapidly becomes shelled.

## BOTANY.

### A. GENERAL, including Embryology and Histology of the Phanerogamia.

**Chemical Difference between Dead and Living Protoplasm.***—What it is which constitutes life, whether it is produced or not by a non-material principle, i. e. by a "force" akin to the natural forces, heat and electricity, are questions which have been agitated, and to answer which theories have been evolved ever since the Microscope revealed to us the apparently extreme structural simplicity of the *physical* basis of life. Dr. O. Loew and T. Bokorny's recognition of a definite chemical difference between the characters of protoplasm before and after death will be interesting to those who have felt the said theories to be unsatisfactory, even if plausible. Dr. O. Loew elaborated last year a theory, according to which protoplasm consists of an aggregation of *aldehydes*, the capability of an intermolecular motion of which was a necessary condition of life, the destruction of this equilibrium resulting in death. To put this to the proof, the two authors above mentioned have now endeavoured to find in living protoplasm the aldehydes demanded by this theory. Nitrate of silver, in a solution of 1:100,000, that is, of a strength too slight to react visibly with hydrochloric or hydrosulphuric acid, was used to test the chemical properties of the protoplasm. Small quantities of the filamentous Algæ *Spirogyra* and *Zygnema* were placed in a litre of this solution; they soon assumed a brown colour, and in twelve hours many of the cells were deeply stained black. A study of the distribution of the reduced silver in the plant shows that the reduction process was most active at the septa between the cells and in the chlorophyll-granules, and at plications in the cellulose walls. If the Algæ are first killed they show no trace of the reaction. If they are kept for five minutes at a temperature of 35° C. the reaction is tolerably active, but at 50° the protoplasm becomes wholly inactive in this respect. This agrees with Max Schultze and Kühne's observation that various low organisms and cells are killed by a heat of between 45° and 48° C., although it must be remembered that Max Schultze found Algæ living at 53° C., and Ehrenberg at 81° to 85° C., and that Naegeli found that *Bacillus subtilis* survived boiling for eleven hours. Besides heat, ether vapour, applied for an hour to filaments dried in blotting-paper, kills them; also an immersion of one hour in either sulphate of copper, sulphuric acid, or caustic soda. In opposition to

* Pflüger's Archiv, xxv. p. 150. Cf. Naturforscher, xiv. (1881) pp. 290-3.

sensitiveness to the alkaline and neutral fluids must be set the persistence of Fungi, Infusoria, Dipterous larvæ, and Copepoda, in lakes in E. California containing almost $2\frac{1}{2}$ per cent. of carbonate of soda.

Contradictory results having been obtained as to the action of veratrin by previous observers, the authors tested it by leaving filaments of Algæ for twelve hours in the weak solution obtained by boiling in water, and found the protoplasm still able to react strongly; the same result followed the substitution of $\frac{1}{10}$ per cent. solution of acetate of quinine ("chinin"); in both cases the protoplasm, when stained black, manifested remarkable disarrangement. The presence of aldehydes in living protoplasm appears to be further indicated by the separation of the metals by it from the dilute solutions of gold and platinum chloride respectively; the reaction with the platinum salt was slight; no reduction occurred with alkaline solutions of lead and copper salts. Leaving *Zygnema* and *Spirogyra*, the authors experimented on other plants. *Cladophora*, in spite of the abundance of chlorophyll in its cells, separated the silver in granules which were generally distributed over the cell. The Moulds yielded uncertain, the Schizomycetes unfavourable results; the Diatomaceæ occasionally precipitated the silver at certain points: these failures were probably due to the slight penetrability of the cell-walls of the organisms. Hairs of plants were found almost as susceptible as the *Zygnema* filaments; those of the leaf-stalk of *Alsophila australis*, after twelve hours' treatment with the silver solution, were found stained deeply in the middle cells, faintly in those of the base and apex; the colour was almost equally distributed within the cells as a rule, but in some cases it occurred most abundantly at their ends, and gradually diminished in amount from thence to the centre. Good results were obtained with the hairs of the corolla of *Primula*, and the stinging hairs of *Urtica;* in the latter the deepest staining took place at the apex of the hair.

To test the behaviour of the protoplasm of the highly organized vegetable tissues, roots and stems of Phanerogams were taken. Seedlings of *Helianthus annuus* were kept for twelve hours immersed almost up to the cotyledons in silver solution; the root became blackened up to this point, but especially deeply at the apex. Split seeds of the same plant which had not germinated, showed, after similar treatment, the presence of the silver in the cells adjacent to the line of section, which appears to show the presence of aldehydes in protoplasm during its *resting* condition. Blossoming twigs of *Salix capræa* and *Cornus mascula*, and twigs of *Syringa vulgaris* with bursting leaf-buds, after being covered with the solution for about half their height, were found blackened on the cut surface; the colour extended to almost all those cells in the branch which contained protoplasm. Of animals, Infusoria were found to reduce silver in a few instances. From the possession of this property of reducing silver by living, as opposed to dead protoplasm, the authors explain life to be produced by the molecules which cause the reaction, and describe these molecules provisionally as "Aldehyde groups."

**Formation and Growth of the Cell-wall.***—F. Schmitz argues in favour of the older theory of apposition as opposed to that of intussusception, in the increase in thickness of the cell-wall. He maintains that cellulose is not formed by secretion, but by metamorphosis out of the protoplasm. This he deduces not only from the processes in those cells which finally become empty, but also from the gradual transformation of the protoplasm into a parietal layer, and from the phenomena that accompany the increase in thickness of the cell-wall. The outermost layer of the protoplasm gradually developes into a stratum constantly increasing in thickness, which is at first still firmly united to the rest of the protoplasm, but which gradually becomes separated from it, and finally adheres to the cell-wall as its innermost thickening-layer, as has already been described by Pringsheim. The formation of partial secondary deposits also takes place, according to the author, by metamorphosis from the protoplasm. In cells of the testa of the seed of *Torenia Fournieri*, which show a thick thickening-band on the two opposite sides, the primordial utricle first of all becomes thicker at these places, a number of granules accumulating in them; a string of a denser substance is then formed at these spots in the superficial layer of the primordial utricle; and this finally becomes the thickening-band.

When a cell divides, a single layer of granules, Schmitz's "microsomes," first collects at the spot where the new wall is formed; this then extends along the wall of the mother-cell, and is finally transformed into the young cell-wall of the daughter-cells by the coalescence of the microsomes and chemical transformation of their substance. Schmitz, however, admits that the protoplasmic disk which bears these microsomes, probably itself becomes the cell-wall by absorption of the substance of the microsomes. Even in those Algæ, as *Cladophora*, *Conferva*, and *Spirogyra*, in which the division-wall is formed gradually, it arises from the protoplasm, a protoplasmic division-wall being gradually developed in the form of an annular disk which becomes constantly narrower, and is finally transformed into cellulose.

Although the author considers he has proved the growth of the cell-wall by apposition, he is inclined to believe that the intussusception theory may be true in some instances. Even in the cases of a so-called centrifugal increase in thickness of the cell-wall, as in the formation of the cuticle of pollen-grains, in the only case examined by Schmitz, that of *Cobœa scandens*, a centripetal process of apposition is possible, since the outermost layer, with its spines and bands, is formed earlier than the cell-wall of the pollen-grain.

Even in the superficial growth of the cell-wall as the cell increases in size, the author considers the intussusception theory not proved, since in many cases a stratification may be observed. The outer older lamellæ of the cell-wall are only momentarily stretched passively, and either remain permanently in the form of a general envelope, as in *Cladophora*, or are thrown off in various ways, as in *Holosphæra* and *Glœocapsa*. In

* SB. niederrhein. Ges. f. Natur- u. Heilkunde, Bonn, Dec. 6, 1880. See Bot. Centralbl., vi. (1881) p. 187.

the apical growth of the cells of *Bornetia scandiflora*, new cap-shaped pieces of cell-wall are constantly being formed at the apex, while the older outer parts only continue to enlarge by stretching.

**Cell-sap and Cell-contents.***—A series of experiments on the nature of the cell-sap by G. Kraus shows that the growth of the cell is always accompanied by absorption of water, and consequent dilution of the cell-sap. The proportion of albuminoids in the cell-sap decreases with the age of the internode, the proportion of free acids exhibiting also a regular decrease, the sap being most acid in the youngest visible internode. The absolute amount of acid, however, increases with growth, acids being continually formed in the growing shoot. The amount of sugar (under which term Kraus includes all the copper-reducing substances of the cell-sap) increases still more, both absolutely and in proportion, but attains a maximum apparently before the maximum of growth.

When a growing shoot is bent, a concentration of the sap takes place at once on the convex side, the sap of the concave side becoming less concentrated; and the increased concentration is accompanied by an increase in the amount of sugar, the sugar being fresh-formed at the moment of disturbance, and often associated with a disappearance of the free acids. Leaf-stalks exhibit the same phenomenon.

**Growth of Starch-grains.†**—A. F. W. Schimper has made a fresh series of experiments in the laboratory of the Johns-Hopkins University at Baltimore on the growth of starch-grains. In many parts of plants which contain chlorophyll, and which are in a growing state, the starch-grains show certain constant peculiarities of structure. They are usually disk-shaped, thick at the margins, irregularly lobed, and sometimes perforated; their thick margins are very uneven, and present under the Microscope a flaky appearance, caused by the sculpture of the surface, and in many cases also by vacuoles. These appearances are due to a partial disintegration, in consequence of the starch being partially used up for the growth of the organ, as is shown by the facts that the grains formed after the retardation or cessation of growth of the organ have not this character, and that a similar structure is seen in the starch-grains of germinating seeds.

After the growth of the starch-containing organ has nearly or quite ceased, the formation commences of definite forms of starch-grains. Either new spherical grains are produced, having no trace of the structure just described; or those already in existence experience a new growth, which however does not take place in the interior of the grain, but in the form of a shining and strongly refractive layer, at first thin, but gradually becoming thicker, formed around the disintegrating grain. This layer repeats at first the irregularities of surface of the underlying grain; but as fresh layers are continually added, these gradually disappear, so that the surface is eventually often quite smooth; but even when mature, the original disintegrated grain can be seen in the middle with favourable illumination.

* Abhandl. Naturf. Ges. Halle, xv. See Bot. Ztg., xxxix. (1881) p. 389.
† Bot. Ztg., xxxix. (1881) pp. 185-94, 201-11, 217-27 (1 pl.).

This structure was observed by Schimper in the starch-grains of the cotyledons of *Dolichos Lablab*, the seeds of *Vicia Faba* and *Phaseolus*, and the medullary parenchyma of *Cereus speciosissimus*.

It follows that the theory of Naegeli is incorrect, that the centre of a starch-grain is the oldest part; growth, on the contrary, takes place by exogenous stratification.

The course of development of a starch-grain is as follows:—1. Its first appearance in the form of a strongly refractive dense body, but not, as Naegeli states, always spherical. 2. Differentiation of the originally homogeneous grain into a central watery nucleus, and a dense peripheral layer. 3. The formation of three layers, of which the central one is always watery, surrounding the grain. 4. Increase in the number of layers, the outermost being always dense. 5. Increase in the amount of water in the centre with the increase in size of the grain.

When starch-grains swell up in water, the deposition of water is, as Naegeli was the first to point out, not equal in all directions, but much greater in a direction parallel to the stratification than at right angles to it. The contrary is, however, sometimes the case with compound grains.

Starch-grains differ from ordinary sphero-crystals in their capacity for swelling; the fibrous crystals which compose them must, therefore, be regarded as crystalloids, which term includes all crystalline bodies capable of swelling. The investigations of the author show that starch-grains consist of radially disposed crystalloids, presenting the crystallization of the starch-substances $C_6H_{10}O_5$, of which there are probably several isomeric. Several circumstances combine to show that the starch-crystalloids always occur in the form of fibrous aggregates, never singly.

**Structure of Stomata.***—A. Tschirsch distinguishes two kinds of stomata, which he terms the *angiospermal* and the *archegonial* type. The first of these is characterized by the outer and inner border of the cuticle being developed, the outer one being usually considerably thickened. In this way is produced the well-known form which occurs in nearly all angiosperms, with an anterior and posterior border, the *eisodial* (*Verhofsausgangöffnung*), and the opisthelial pore (*Hinterhofsausgangöffnung*), and a central fissure. The second type is characterized by the outer wall of the guard-cells being very much thickened, while the inner wall usually consists of only a thin lamella, and by the guard-cells being considerably separated in their central part, but not at the poles. The outer border of the cuticle is not developed into a ridge, but is rounded off; while the inner one is usually altogether wanting. It follows that there is never a posterior border, and only occasionally an anterior border, as in some conifers. The central fissure then opens directly into the subjacent cavity. This kind occurs in archisperms (gymnosperms), and in vascular cryptogams. Gymnosperms are, therefore, as regards the structure of

* Verhandl. Bot. Ver. Prov. Brandenburg, 1880, p. 116. See Bot. Centralbl., vi. (1881) p. 341.

the stomata, more nearly related to vascular cryptogams than to angiosperms.

**Bordered Pits.***—C. Mikosch thus sums up the results of an investigation of the origin and structure of bordered pits:—

1. The first clearly differentiated layer in the young wall of a wood-cell is the inner wall; at the same time, or later, another layer or system of layers arises, constituting the central lamella. Between this and the inner wall is a very watery substance, from which the thickening-layers are subsequently formed.

2. The origin of the bordered pit is a simple pore, formed in the primary wall. The canal of the pit is developed from the pore by the growth of definite portions of the cell-wall, which proceeds in various ways; the border, by resorption of certain parts of the division-wall of the pore, which subsequently becomes thicker. The form of the border is determined by that of the thickening of this piece of wall.

3. The border is clothed on its inner surface either only by the inner walls of adjoining cells, or on one side by the middle layer of the central lamella, which is united with the inner wall; on the other side, by the inner wall of the adjoining cells alone; or finally, at the mouth of the pit-canal, the inner walls play the part of lining-membranes, while at the other surfaces the thicker layers of the central lamella do so.

4. The middle layer of the central lamella may cross the border either in the form of a thin plate, or of one thickened in the middle, and then divides it into two equal halves.

5. The bordered pit is originally also closed on both sides by the inner wall of adjoining cells; in some cases, where the above-mentioned plate divides the border in the middle, a treble enclosure occurs.

6. When the bordered pit is mature, the closing membranes may either remain (closed pits), or they have partially or entirely disappeared (open pits).

**Gum-passages in the Sterculiaceæ.**†—B. Ledig has examined the origin, distribution, and structure of the gum-passages in the following species belonging to the Sterculiaceæ, viz. *Astrapœa Wallichii*, *Pterospermum acerifolium*, *Dombeya mollis*, *Heritiera macrophylla*, *Brachychiton populneum*, *acerifolium*, and *Delabechei*, *Helicteres involucrata*, and *Ruizia variabilis*, and has found a general resemblance to that already described in the allied genus *Tilia*. They occur chiefly in the pith and cortex of the ultimate branches and of the leaf-stalks. *Sterculia Balanghas* is distinguished by their entire absence from the leaf-stalk, their place being supplied by laticiferous canals.

With slight variations in different species, the mature gum-canals of the Sterculiaceæ have the form of roundish but not sharply defined cavities in the isodiametric parenchyma; but the neighbouring cells

* SB. Akad. Wiss. Wien, June 2nd, 1881. See Bot. Ztg., xxxix. (1881) p. 466.

† Bot. Centralbl., vi. (1881) pp. 387–9.

are somewhat flattened tangentially, this being most strikingly the case with the layer of cells which immediately surrounds the canal. Both in older and younger canals, portions of non-deliquesced cell-wall are constantly found projecting into them, from which the conclusion may be drawn that the canals are formed in the young organ at the time of the differentiation of the tissues while they increase in size from the resorption of the surrounding tissue.

In the youngest recognizable stage of development, the gum-canals have the appearance, on transverse section, of highly refractive spots. Greater magnification distinguishes the separate cells, which contain a strongly refractive substance, the cell-walls being already very transparent. The addition of alcohol shows subsequently masses of gum collected in the cells, the greater part of the cell-walls then deliquescing, although portions still remain. The gum forms at first a homogeneous mass, in which, however, are often imbedded remains of the protoplasm. The adjoining cells have now undergone changes which prepare them for resorption. Coalescence of canals was frequently observed, especially in the stipules of *Pterospermum*, large portions of the tissue becoming converted into lacunæ, traversed by a reticulation of isolated rows of cells.

**Rosanoff's Clusters of Crystals.*** — According to K. Demeter, these clusters of crystals occur in *Bœhmeria biloba*, *B. japonica*, *Leucosyke candidissima*, *Mercurialis hirta δ heterocarpa*, *Elatostema eurhynchum*, and most beautifully in *Bœhmeria celebica* and *Debregeasia dichotoma*, all belonging to the Urticaceæ.

The pith of *Bœhmeria celebica* consists of large, thick-walled, polyhedral, pitted parenchymatous cells, between which lie more elongated cells, of smaller diameter, parallel to the axis of the stem. These contain the largest number of Rosanoff's clusters of crystals, attached to ridges of cellulose, the number, direction, and strength of which are variable. They may occur in considerable numbers, but are seldom altogether wanting. Their breadth is in inverse proportion to their length, and they are often tubular. Their chemical nature is similar to that of cellulose; usually they are somewhat lignified, like the walls of the medullary parenchyma. Where the clusters are small, these ridges are expanded like a funnel at the spot where they pass over into the cellulose envelope of the clusters. These ridges of cellulose are sometimes found without any clusters of crystals, and in cases which exclude the possibility of any having fallen off.

**Assimilating Tissue of Few-leaved Plants.†**—H. Pick has investigated the anatomical structure of the tissue of plants with but few leaves, especially species of *Casuarina*, *Ephedra*, and *Spartium*, the leafless species of *Acacia*, *Asparagus*, *Ruscus*, and *Phyllanthus*, Papilionaceæ, thorny forms of *Colletia*, *Muhlenbeckia platyclados*, and

* 'Magyar növéntyani Lapok,' v. (1881) p. 33. See Bot. Centralbl., vi. (1881) p. 341.

† Pick, H., 'Beiträge zur Kenntniss der assimilirenden Gewebes armlaubiger Pflanzen,' Inaug.-Dissert., 34 pp., Bonn, 1881.

*Rubus australis*, and finds the external peculiarities of form connected with modifications of anatomical structure.

The stem of the species examined of *Spartium*, *Casuarina*, and *Ephedra*, contains a strongly developed palisade-parenchyma in the cortex, and a large number of stomata in the epidermis, the collenchyma being also replaced by sclerenchyma. In species with thick stems, chlorenchyma is developed on both sides equally, and sclerenchyma abundantly. Stems with few or no leaves exhibit more or less the structure of leaves; the species of *Asparagus* and *Colletia* have palisade-parenchyma in the cortex, and a large number of stomata. The phyllodes of *Acacia* and the leaf-stalk of *Rubus australis* also possess palisade-parenchyma. All the species examined have numerous intercellular spaces in the cortical parenchyma. As the amount of foliage decreases, the cortical parenchyma assumes more and more the palisade form, and the collenchyma becomes replaced by sclerenchyma. When the collenchyma forms a closed ring, the number of stomata in the cortex is small. The number of stomata also goes along with the abundance of intercellular spaces and of brightly coloured chlorophyll-grains in the parenchymatous cells.

The palisade-form of the parenchyma the author considers peculiarly favourable for access of light, diffusion of gases, and the rapid transport of reserve food-materials—in other words, for assimilation. The occurrence of sclerenchyma in the place of collenchyma he explains on the ground of economy of space for the process of assimilation.

Finally, the author has determined that plants with few leaves give out most oxygen, consequently assimilate most. The exclusion of light caused the reserve starch to be stored up in the course of two or three days, while in plants with abundant foliage this takes place only in from eight to fourteen days.

**Structure of Climbing Plants.***—A close examination of a large number of species convinced MM. Westermaier and Ambronn that, notwithstanding the fact that they belong to so many widely separated families, there are yet points of anatomical structure in which all climbing plants are more or less distinguished from others.

One noteworthy feature is the large size, at least in older stems, of the vessels. In many instances these have a diameter of 200–300 $\mu$, and in some instances (*Hyponthera guapeva* and some passion-flowers) they even exceed 0·5 mm. The essential constituent of the phloem, the sieve-tubes, are in general remarkably well developed in climbing plants. There is some difference in the development of the medullary rays and the xylem. These differences in internal structure are no doubt connected with the peculiarities of their external morphology, and with the physiological peculiarities connected with their power of climbing.

**Monotropa Hypopitys.**†—Dr. F. Kamienski has reinvestigated the structure of the vegetative organs of this plant, in order to determine the vexed question of the mode in which it obtains its nutriment.

* Flora, lxiv. (1881) pp. 417–30. † Bot. Ztg., xxxix. (1881) pp. 457–61.

He finds that it has no haustoria, and is no true parasite, but a saprophyte, i. e. a non-chlorophyllaceous plant growing in humus. The root-fibres appear to be invariably clothed with a dense weft consisting of the mycelium of a fungus, which covers the extremities of the fibres like a cap; it is not, however, parasitic upon the root. The parasitic nature of *Monotropa* has been wrongly inferred from the fact that its roots often coalesce in their growth with roots of the firs beneath which it grows that have become deformed and partially destroyed by a parasitic fungus.

**Influence of Light on Germination.***—Dr. Stebler states, as the result of a series of observations, that in the case of certain seeds, especially of grasses, light promotes their germination, while in the dark they either do not germinate at all or only with difficulty. This was observed in the seeds of *Festuca*, *Cynosurus*, *Alopecurus*, *Holcus*, *Dactylis*, *Agrostis*, *Aira*, *Anthoxanthum*, &c. In the case of seeds which germinate easily and rapidly, like those of peas, beans, clover, &c., he was unable to detect that light had any advantageous influence.

**Influence of Intermittent Light on the Formation of Chlorophyll.**†—Wiesner considers that the formation of chlorophyll by the action of light is a photo-chemical inductive process, because the exposure for $2\frac{1}{2}$ minutes of etiolated barley and oat seedlings to continuous light did not result in the formation of chlorophyll, but when, after a dark interval, light was again allowed to act, then chlorophyll was produced. The effect of the light was, therefore, to induce the formation only, as at the end of a single period of illumination no more chlorophyll was observable than at the beginning. Again, with continuous illumination, the first trace of chlorophyll was only observable after five minutes. Long-continued illumination, and illumination in excess, will, however, give rise to the production of this substance.

**Decomposition of Nitrates by Plants in the Dark.**‡—It is well known that green plants grown in the dark do not increase in weight, owing to their want of power to decompose the carbonic acid in the air. Boussingault has found that when seeds are sown in the dark in soil containing nitrates, they do partially decompose these nitrates.

**Influence of Gravitation on Plants.**§—F. Elfving has tried further experiments on the influence of gravitation on positively and negatively heliotropic organs. As an instance of the latter he took *Phycomyces nitens*, and found that, when the position was reversed, growth in length was retarded by gravitation. This effect can be observed directly, or by the secondary result when the plant is restored to its normal position. The next experiments were for the purpose of ascertaining whether gravitation exercises any influence on

* Verhandl. naturwiss. Vereins Zürich, 1881. See Bot. Ztg., xxxix. (1881) p. 469.
† Journ. Chem. Soc. Abstr., xl. (1881) p. 930, from Bied. Centr., 1881, p. 352.
‡ Ann. Chem. et Phys., xxii. (1881) p. 433. See Naturforscher, xiv. (1881) p. 237.
§ Acta Soc. Scient. Fenn., xii. (1880). See Bot. Ztg., xxxix. (1881) p. 176.

the growth in length of positively or negatively geotropic organs, when in a vertical position of equilibrium. Two modes of investigation agreed in answering this question in the negative. Finally, the author instituted a series of experiments on the effect in producing curvature of gravitation and of centrifugal force, the conclusion arrived at being that the curvature is increased by an increase of the external force.

**Influence of Physical Conditions on the Forms of Water-plants.***—Dr. W. Behrens illustrates by several examples the rule that water-plants become modified in the forms of their leaves and other parts according to the increase or diminution in the movement of the water which they inhabit. He first points out that the constant kidney-like outline of the leaves of the Frog's Bit, *Hydrocharis morsus-ranæ*, is correlated with its invariable association with still water; the same is the case with its South American representative, *Trianea bogotensis.*

*Potamogeton natans* is a familiar instance of the converse, the breadth of its leaf being as 1 : 1½ of the length in still water, while in ditches in which a good current runs the leaf is narrow and lancet-shaped; in another species the breadth is as 1 : 3 of the length.

Plants of the sub-genus *Batrachium* (*Ranunculus*) afford especially good examples of the above-named principle, as many of the species frequent all kinds of water, and most of them possess two kinds of leaves, the broad floating and the deeply cut immersed ones. Of the five species inhabiting Central Europe, *B. aquatile* (*Ranunculus aquatilis*) is the most variable in form. It has two chief varieties; the one, *B. aquatile* var. *heterophyllum*, has two kinds of leaves, viz. flat floating and immersed linear. It occurs chiefly in slow-flowing ditches and streams, and in sluggish branches of small rivers. Where the motion of the water is very slow, the floating leaves are peltate and almost circular, the edge marked with but five slight incisions, forming the sub-variety *peltatum;* in more rapid streams these characters are modified, and the leaves are more deeply cut, more strongly lobed and jagged. In somewhat faster streams the floating leaves become quinquelobate (sub-variety *quinquelobatum*). In tolerably quick-flowing ditches, the basal lobes of these leaves are lost, and the three remaining are wedge-shaped, but are themselves deeply notched; the leaves are smaller than in the preceding form (sub-variety *tripartitum*). Another form, found in similar localities, shows a further advance in the same direction; the leaves, which are trilobate and deeply notched when young, have the points which separate the notches much prolonged as they grow older, and approximating closely to the hair-like tips of the immersed leaves, though they still preserve a web of green parenchyma, uniting the bases of the lobes (sub-variety *laciniatum*). In very rapid water this series of modifications is concluded by the production of the *B. aquatile* var. *trichophyllum*, with but one kind of leaves, which are immersed and hair-like. A similar result is produced by

* Jahresber. Naturw. Ges. Elberfeld, 1880. Kosmos, vii. (1880) pp. 466–71.

the drying up of the pools or ditches in the spring; the conditions then become those of terrestrial growth; the stem becomes erect, and is thickly clothed with bright green leaves, divided into many short, somewhat stiff, filamentous points, constituting a variety *B. aquatile* var. *succulentum* (the *B. succulentum* of systematists, the *Ranunculus pantothrix* of De Candolle). Besides these variations in the *form* of the leaves, this plant is also subject to variations in their *texture*. Thus, in some cases, when removed from the water, the immersed leaves collapse and fall together like the hairs of a wet brush, while in others their rigidity causes them to remain distinct; this circumstance is due to differences in the development of the fibro-vascular bundles in the two cases. The varieties thus formed may be termed *laxa* and *rigida*, respectively. Variations in the flowers are also brought forward by the author, constituting the varieties *macranthum* and *micranthum*, but their connection with external conditions is not shown. But allowing these, as well as the variations indicated by the terms *rigida* and *laxa*, to occur in the case of each of the above-mentioned varieties and sub-varieties, the total number of actually occurring permutations and combinations of these different states of variation is set down as twenty-two in the single species *B. aquatile*; and the author declares that more might still be added from fresh water, while the brackish-water forms have not been even mentioned. He finds in this extraordinary variability the best possible arguments against the doctrine of constancy of species. A larger and more detailed work on the subject is promised.

**Respiration of Plants.***—M. Borodin maintains, as the result of a fresh series of observations, that the energy of respiration of a leafy shoot is, under equal external conditions, a function of the amount of carbohydrates present in the plant. In confirmation of this view, he adduces the fact that red light and a greater intensity of light have a more powerful effect than blue or a less intense light. Direct experiments showed that when a plant was exposed for a long period to an atmosphere rich in carbonic acid (at least when the proportions did not exceed 7 per cent.), in the dark, no acceleration of the respiration resulted, such as always takes place in the ordinary air under the influence of light. Respiration does not, therefore, depend on the carbonic acid as such, but on its decomposition in the light.

Further experiments were made by the author on the absorption of carbonic acid by air-dried parts of plants, especially seeds. He found absorption to take place to a considerable extent, the carbonic acid being again given off into air, which contained but little of that gas. This absorption took place in the case of seeds rich in starch or oil. Air-dried seeds were found not to respire. Among other gases, the absorption of hydrogen by air-dried seeds was determined, but in inconsiderable quantities.

**Colours of Spring Flowers.**—Mr. A. W. Bennett, in a paper read at the York meeting of the British Association, suggests an explana-

* Mém. Acad. Imp. Sci. St. Pétersbourg, xxviii. (1881) 54 pp. (2 pls.).

tion of the prevalence of certain colours in spring flowers, as contrasted with those of autumn and summer.

The common spring flowers of England were reckoned as 64, and these were included, as regards colour, under five heads, viz. (1) white, (2) green, (3) yellow, (4) red and pink, (5) blue and violet. The proportion was found to be as follows:—white, 26, or 40·5 per cent.; green, 9, or 14·1 per cent.; yellow, 13, or 20·3 per cent.; red and pink, 5, or 7·8 per cent.; blue and violet, 11, or 17·4 per cent. The chief feature in this table is the great preponderance of white, as compared with other times of the year; yellow is also greatly in excess, while the number of red and pink flowers is extremely small. Taking, now, 50 early spring Swiss flowers, the following list is obtained:—White, 18, or 36 per cent.; green, 1, or 2 per cent.; red and pink, 10, or 20 per cent.; blue and violet, 8, or 16 per cent. The chief points of contrast in this list, as compared with the first, are the smaller proportion of white and green, and the very much larger proportion of red and pink. White and green differ from all the other shades, as indicating rather the absence than the presence of colour. Seeing, therefore, that the bright-coloured fluid pigments of petals are formed only under the influence of a sufficient supply of light and heat, the large proportion of green and white in our early spring flowers is easily accounted for. Then, with regard to yellow, M. Flahaut observes that "a solid insoluble pigment, the xanthine of Frémy and Cloëz, is in the first place to be distinguished from all the soluble colouring matters, all of which are acted on very readily by reagents, and which are usually formed only in the epidermal cells." This xanthine Frémy states to occur always in the "form of clearly defined grains, occasionally in the epidermal, much more often in the deeper-lying cells, slowly soluble in alcohol and potassa. It is in all probability a modification of chlorophyll." The plants in which he found this substance are all early-flowering spring plants. The colours which pre-eminently distinguish our summer and autumn flora, the reds, pinks, blues, and some yellows (not due to xanthine, but to a soluble yellow pigment), are caused by the presence of substances which require both a strong light and a high temperature for their production; and Batalin has shown this to be especially the case with the red colouring substance.

The difference between the prevailing colours of the spring flowers in England and in Switzerland is due to the same cause. Owing partly to the spring being a month later, partly to the more southern latitude and consequent greater elevation of the sun, partly to the clearer air of a high altitude, the light which opens the earliest spring flowers is much stronger in Switzerland than in England.

**Action of Anæsthetics on the Sensitive Organs of Plants.***—In order to determine the question whether the effect of chloroform and ether in suspending the irritability of sensitive organs is due to the cold produced by their application, C. Cugini used them in an atmosphere of the steam of boiling water. In the cases both of the

* Nuov. Giorn. Bot. Ital., xiii. (1881) pp. 288–91.

leaves of the Sensitive Plant and of the stamens of *Berberis* and *Mahonia*, he found that these agents had precisely the ordinary effects in arresting the sensitiveness of the organs. He concludes, therefore, that the phenomenon of sensitiveness in plants is due to similar causes as the same property in animals, the protoplasm in both cases being sensitive to impressions from substances with which it is not in actual contact.

**Albuminoids of the Fig.***—The fact that in Calabria and other parts of Southern Italy fresh or dried figs form almost the entire diet of the labourers, who are nevertheless able to perform the hardest labour, gives interest and importance to an examination of their nutritive properties.

The pseudocarp consists, according to Malerba, of elongated polygonal cells, which increase regularly in size from the epidermis inwards, and have a parenchymatous character. Among these are a number of fibro-vascular bundles, which branch from the base of the pseudocarp, afterwards anastomosing. Between these are laticiferous vessels, the contents of which have not been accurately examined; but the presence of nitrogen and of sugar has been determined.

The albuminoids were extracted from the fig by means of artificially prepared peptic acid, thus causing them to be peptonified. The average of four experiments gave the proportion of albuminoid in the fig as 1·825 per cent. The pancreatic juice dissolved them more rapidly than artificial peptic acid. The author was unable to determine the exact nature of the albuminoid; but he believes he has detected a mixture of three kinds or forms, one of which is soluble in distilled water, with the characters of legumin, another soluble in acidulated water, while the third is insoluble in distilled water.

The skin and pedicel contain a large proportion of the albuminoid substance, the flesh of the pseudocarp a larger proportion of sugar.

**Paracholesterin.†**—J. Reinke and Rodewald laid masses of the protoplasm of *Æthalium septicum* in alcohol, by which a substance was extracted which coloured the alcohol yellow. On evaporating the alcohol there remained a friable mass, from which ether extracted a brownish-yellow oil. In this were formed in the course of a few days colourless acicular crystals, composed of a substance apparently isomeric with animal cholesterin and with isocholesterin, although it may possibly be an adjacent member of a homologous series. The discoverers gave it the name *paracholesterin*.

**Formation of Xanthin in the Germination of Seeds.‡**—According to G. Salomon, fibrin may be split up into xanthin and hypoxanthin. Since the products of animal fermentation are to a great extent the same as those produced in the germination of seeds, it might be assumed that xanthin would be found in seedlings. This

* Rend. R. Acc. scienze fis. e mat. Napoli, xx. (1881). See Bot. Centralbl., vi. (1881) p. 340.

† Liebig's Ann. d. Chemie, ccvii. (1881) pp. 229–35.

‡ Verhandl. Bot. Ver. Prov. Brandenburg, 1880, p. 104. See Bot. Centralbl., vi. (1881) p. 339.

the author has confirmed in the case of young seedlings of *Lupinus luteus*, in which he found not only xanthin, but apparently also hypoxanthin, at the time when the root was beginning to emerge from the testa. Two observations failed, on the other hand, to detect more than a trace of xanthin in dormant lupine-seeds. The xanthin could be detected in the young plant for some weeks, and in the aerial portion as well as the root. The substance was found also in officinal extracts of plants, so that it may be assumed, with strong probability, that it is also a constituent of mature plants.

**De Candolle's 'Phytography.'***—By "phytography" Alph. de Candolle understands "the art of describing plants, considered from different points of view;" and his book of 30 chapters and nearly 500 pages is devoted to defining the principles which ought to be followed by botanists in this respect, with a view to the improvement of their writings.

In his preface he refers to the large number of books relating to anatomy which are now relegated to the out-of-the-way corners of libraries. The cause is plain. The Microscope and the mode of using it having made such great progress, what was formerly observed is considered to have been badly seen. Each improvement of the instrument has produced in this part of science the same effect as the changes in fire-arms have produced in books treating of the military art. It has been necessary to recommence from fifteen years to fifteen years, and the works of Kieser, Moldenhauer, Meyen, &c., are already in the shade, as those of Grew and Malpighi were before them. Observations made by ordinary vision retain their value, but what is seen by the aid of magnifying powers depends upon the point to which they have been brought. A single discovery of the optician may put aside excellent works, which pass into the condition of historical documents.

Under the head of "Remarks on the manner in which the facts observed by the Microscope are described," the author comments upon the extent to which microscopical descriptions have suffered in modern times, and the want of the same method that has been established in the case of macroscopical. Even in the case of microscopists who more nearly approach the Linnean system of description, their style is very verbose. Schacht and Payer are admittedly two of the clearest and briefest, but the author gives three instances from their works, taken by chance, in which 85 words and 516 letters, 93 words and 471 letters, and 110 words and 517 letters, are easily expressed in the Linnean style by 37 words and 253 letters, 30 and 210, 48 and 324. No library will be able to contain the books if the 100,000 species are treated in the way referred to. "Cells ellipsoidal, contiguous" is shorter, but conveys as much as "The cells are ellipsoidal and do not show any visible interstices," and "vascular bundles in a complete ring" than "the vascular bundles are disposed in a complete ring," or, as may be found in many works, "If the organ is cut transversely, and observed with a power of only 80 times, we shall see

* De Candolle, A., 'La Phytographie.' 484 pp. (8vo, Paris, 1880.)

the vascular bundles, which are arranged in a perfect circle around the pith." All that has been published on the microscopical organs for the last fifty years might be included on twenty or twenty-five volumes for every hundred that really exist. The only redeeming feature is that the plates with their descriptions have been so good as to constitute a clear *résumé* of the book, and to render a reference to the text unnecessary.

On attempting to add to the Prodromus details relating to the microscopical organs, the author found it impossible of accomplishment, for these reasons: want of clearness in the names used for the parts; some of the words used impossible to translate into another language, particularly Latin; omission of some characters; the number of species in which a given character has been seen is so small that it is impossible to decide whether it can be attributed to a single species, a group of species, a genus, a tribe, or a family; and lastly, the names are often doubtful, anatomists not giving themselves the trouble to verify the name or to cite the authority for it.

Microscopists, it is complained, turn in a circle of about 2000 species of Phanerogams, that is, in a fiftieth part of the whole.

The author gives the following suggestions for the guidance of observers:—(1) Investigate the anatomical points from species to species in the same genus, then from genus to genus, family to family, cohort to cohort. (2) Examine the large herbaria for the correctness of the names, &c. (3) Use the Linnean style for descriptions, as is already done in the case of Cryptogams. (4) Do not multiply needlessly the names of organs, and above all, do not displace an existing name of Greek or Latin origin by a new one. (5) Write with clear divisions, *résumés*, and indices.

## B. CRYPTOGAMIA.

**Classification of Glœophytes (Thallophytes).***—C. Gobi objects to Endlicher's term Thallophyta for the lowest class of Cryptogams, on the ground that the higher seaweeds possess a true stem and branches; while on the other hand, in many Muscineæ and some flowering plants, as *Wolffia*, the vegetative system consists of a thallus. He proposes to substitute it by *Glœophyta*, founded on the strong tendency of the cell-walls to gelatinize.

Gobi's system of classification is founded, in the main, on the same principles as De Bary's, but differs in some points.†

The series of Chlorophyceæ commences with the group of *Mobilia*, distinguished by their power of spontaneous motion. The simplest form of this is the unicellular *Hæmatococcus* or *Chlamydococcus*, belonging to the series *Agamæ*, with two kinds of spores. The five primary groups of *Cyanophyceæ*, *Chlorophyceæ*, *Phæophyceæ*, *Rhodophyceæ* (Florideæ), and *Fungi*, may again be classified, by a cross-division, in accordance with Sachs's proposal, into the *Agamæ*, *Isogamæ*, *Oogamæ*, and *Carposporeæ*, dependent on the mode of reproduction,

* Bot. Ztg., xxxix. (1881) pp. 489–501, 505–18.

† See this Journal, *ante*, p. 273.

though some members are wanting. Each of the five groups must not be regarded as a direct line, but rather as a ramifying system. They are distinguished by the nature of their colouring matter, the Fungi being destitute of chlorophyll.

The Fungi have their lowest representative in the agamous Saccharomycetes and Chytridiaceæ, through which they are allied to the agamous Chlorophyceæ. The Schizomycetes do not belong to the Fungi, but are, as Cohn regards them, the agamous stage of the non-chlorophyllaceous Cyanophyceæ. The Myxomycetes are regarded as an isogamous branch of the Chytridiaceæ.

The Chlorophyceæ, commencing with agamous forms, advance to the most highly differentiated carposporous Batrachospermeæ. The isogamous and oogamous Chlorophyceæ are at the present time unknown, and have probably died out. *Hydrurus*, the mode of reproduction of which is at present unknown, may probably belong here.

The Phæophyceæ are also connected with the Chlorophyceæ through their lowest form, *Chromophyton*, and close with the Dictyotaceæ in the oogamous stage. In this series alone is the carposporous stage unknown. The Bacillariaceæ form a small subordinate branch of the Phæophyceæ, branching off from the lower agamous stage, somewhat in the same way as the Conjugatæ in the Chlorophyceæ.

The most fully represented series in the whole class is the Chlorophyceæ, which can be divided into six sub-series, each commencing in the agamous stage, but not all advancing to the same degree of development. The highest type of one of these series, the Characeæ, forms the transition to the Bryophyta or Muscineæ, and thence to still higher forms.

### Cryptogamia Vascularia.

**Sadebeck's Vascular Cryptogams.***—We can only here call attention to the publication of a considerable instalment of this most important work. The portion at present published is arranged under the following heads:—1, Introduction; general review of the process of development; 2, Structure of the Spores; 3, Germination; 4, Prothallium; 5, Sexual Organs; 6, Development of the Embryo; 7, Vegetative Organs; 8, Sporangia. Under each of these heads the subject is treated with a great amount of detail.

**Collateral Vascular Bundles in the Leaves of Ferns.**†—G. Haberlandt gives the following general results of his investigations on this point.

1. In the lamina of the leaf of all ferns examined (belonging to all the families), the smaller vascular bundles are collateral, or at least highly eccentric, in such a way that the hadrom (xylem) faces the upper side, the leptom (phloem) the under side of the frond.

2. The transition from the collateral structure of the small bundles of the leaves to the concentric type of those of the stem, is the

* Sadebeck, R., 'Die Gefässkryptogamen.' Lief. 2–6, pp. 147–326. (Breslau, 1880.)

† SB. Akad. Wiss. Wien, June 17, 1881. See Bot. Ztg., xxxix. (1881) p. 467.

result of the conducting bundles in the primary veins of the leaf, and also frequently those of the leaf-stalk, having an eccentric structure. The layer of phloem which surrounds the xylem is much more strongly developed on the under than on the upper side.

3. The history of development of the collateral bundles in ferns is completed in the same way as in flowering plants. The differentiation of the xylem and phloem begins (in transverse section) at two opposite points of the cambium-bundle, and advances centripetally in relation to the action of the bundle.

4. A general parallel may be drawn between the dorsiventral structure of the mesophyll and the collateral-eccentric development of its vascular bundles. The more conspicuous the dorsiventrality of the assimilating system, the more striking is the collateral-eccentric structure of its conducting bundles.

5. It results from these observations that, certainly in the case of ferns, most probably in that of flowering plants, the collateral structure of the vascular bundle, and its origin in the flatly expanded lamina of the leaf, is a primary anatomical fact. The anatomico-physiological dorsiventrality of the lamina is thus represented also in the structure of its conducting bundles.

**Phyllocladus.***—T. Geyler has fully investigated the structure of *Phyllocladus trichomanoides.* The scale-leaves on the primary axis dry up and fall off early. They are arranged spirally, as are consequently the cladodia formed in their axils. There is, however, a considerable space in which the axillary cladodia are wanting, followed by one in which they are crowded and almost verticillate. The cladodia themselves form a system of secondary and tertiary branches, and so on, in the axils of corresponding scale-leaves. The branches of the weaker primary cladodia are arranged in a single plane, while with the more vigorous cladodia this is the case only in the lower part; in the upper part the arrangement is spiral, that part of the cladodium having a round section. In the next year, such a cladodium developes at first sterile leaves, followed by a number of almost verticillate secondary cladodia.

In seedlings, after the first pair of bi-nerved cotyledons, acicular leaves were produced, and in the axils of some of these, cladodia varying greatly in their distance from one another. In shoots of the third year these acicular leaves gave place to others more resembling the scale-leaves of older plants. The leaves borne on the first formed cladodia differ in form from those produced subsequently. After the third year three-lobed cladodia are formed; and later some are even many-lobed, resembling a pinnate leaf.

The author's description of the fibrovascular bundles does not differ from that of previous observers.

**Hibernating Prothallia of Equisetum.**†—In view of the probable genetic connection of vascular cryptogams with the Muscineæ, and

* Abhandl. Senckenberg. Ges., xii. (1880) pp. 11–17 (2 pls.). See Bot. Centralbl., vi. (1881) p. 313.

† Oesterr. Bot. Zeitschr., xxxi. (1881) pp. 245–8.

especially with the Hepaticæ, any abnormal development of the prothallia of the former acquires special interest. A. Tomaschek has induced prothallia of *Equisetum* to hibernate by growing them in a warm situation. Under these conditions they attain a large amount of independence, and produce new individuals abundantly by budding. In *Osmunda regalis* these readily separate themselves, and propagate independently, as is the case with many frondose Hepaticæ. He was able to maintain the life of prothallia of *Equisetum variegatum* through a whole year, during which they attained a large size, and showed a strong disposition to bud, producing but few archegonia, which all aborted.

### Muscineæ.

**European Species of Radula.***—Nees von Esenbeck described only a single species of *Radula*, in which the male branchlets occur on the same stem as the female. Several forms were subsequently found, differing from the original one in some microscopic characters, and especially in all being diœcious. J. B. Jack now describes seven species, with the following distinguishing characters:—

1. *R. complanata* (Dum.) Gottsche. Parœcious. Sub-pinnately branched; leaves patent; superior lobe rounded. Yellowish green.
2. *R. Carringtonii* Jack n. sp. Diœcious. Sub-pinnately branched; leaves patent; superior lobe rounded. Dusky olive-coloured.
3. *R. Aquilegia* Taylor. Diœcious. Sub-pinnate; leaves somewhat erect; superior lobe obovate-rounded, with recurved margin. Olive-coloured.
4. *R. commutata* Gottsche n. sp. Diœcious. Dichotomously branched; leaves somewhat erect, superior lobe obovate-rounded. Yellowish green.
5. *R. germana* Jack n. sp. Diœcious. Sub-pinnately branched; leaves somewhat erect, superior lobe obovate-rounded. Perianth obconical. Yellowish green.
6. *R. Lindbergiana* Gottsche. Diœcious. Sub-pinnately branched; leaves somewhat erect, superior lobe obovate-rounded. Perianth obovate. Green.
7. *R. voluta* Taylor. Diœcious. Pinnately decomposite; leaves patent, superior lobe rounded-cordate, somewhat wavy, prolonged transversely beyond the stem. Pale green.

The species are then fully described in detail.

**Structure of Marchantieæ.**†—The concluding part of Leitgeb's work on the Hepaticæ is devoted to the Marchantieæ, and to general remarks on the whole group. In the first portion he describes in full the structure of fifteen different genera.

As regards the general structure of the group, Leitgeb fully establishes the existence of one or two apical cells. There are, apparently, in all Marchantieæ two kinds of branching, dichotomous and central, the habit of the plant being determined by the prevalence of one or the other.

* Flora, lxiv. (1881) pp. 353–62, 385–400 (2 pls.).

† H. Leitgeb, Unters. üb. die Lebermoose. 6 Heft. Die Marchantieen. (Graz, 1881) 158 pp. (11 pls.) See Bot. Ztg., xxxix. (1881) p. 319.

The thallus is divisible into three distinct layers, the air-chamber layer to which the stomata belong, the close tissue (without interstices), and the ventral cortical layer. In the second of these are found in all Marchanticæ the mucilaginous organs described by Goebel, of the function of which but little is known, and the oleaginous bodies of Pfeffer. The third is more or less sharply differentiated, and consists of one or more layers of cells. The leaf-like lamellæ on the ventral side of the thallus are not properly leaves, being homologous not to the leaves of the Jungermannieæ, but to the ventral scales of the Riccieæ. The rhizoids are always of two kinds, ordinary and conical.

There is nothing fresh of importance respecting the fructification. The receptacles, while still sessile, are bordered by "laciniæ," or enveloping scales; these are dorsal trichomes, both in those genera where the receptacles are purely dorsal structures, and in those where the apex of the shoot persists on the receptacle; while in those where the receptacle corresponds to a branch-system, the outer enveloping-scales certainly, and probably the inner ones also, are modified ventral scales. The envelope of the archegonia arises, as in the Riccieæ, by an overgrowth of the sexual organs, in consequence of the luxuriance of the adjacent parts of the thallus; while, on the contrary, the "perianth" of the single archegonium is, in *Marchantia* and *Preissia*, a product of the pedicel of the archegonium. The development of the sexual organs follows exactly the type of *Riccia*. The description of the development of the sporogonium corresponds to that of earlier observers. The bursting of the capsule takes place either by teeth, in consequence of the formation of several longitudinal slits proceeding from the apex (in all the genera with fibrous thickening of the walls), or by the separation of the apical third of the capsular wall in the form of a lid (in the genera with unthickened or angularly thickened cell-wall). The splitting of the capsule is not similar to that in the Jungermannieæ.

As regards classification, Leitgeb proposes to abolish the division into Lunularieæ, Jecorarieæ, and Targionieæ. He prefers to include *Plagiochasma*, *Reboulia*, *Grimaldia*, *Duvalia*, and *Fimbriaria*, into one section under the name *Marchantieæ operculatæ*, distinguished by the upper part of the capsular wall being sometimes thrown off in one piece, sometimes breaking up into irregular plates, the lower part always remaining entire. The second division, or *Astroporæ*, including the genera *Sauteria*, *Peltolepis*, and *Clevea*, is distinguished by the stellate form of the stomata, caused by the strong thickening of the radial walls of their marginal cells. In the third and highest division, or *Compositæ*, the receptacle is formed from a branch-system; it includes the genera *Fegatella*, *Lunularia*, *Dumortiera*, *Preissia*, and *Marchantia*. Finally, the genera *Targionia* and *Cyathodium* make up the *Targionieæ*, in which the fructification stands on the margin of the thallus, and is not borne on a receptacle. The whole family of Marchantiaceæ is, therefore, divided into three groups as follows:—

1. *Riccieæ* (Riccia, Ricciocarpus, Oxymitra).

2. *Corsinieæ* (Corsinia, Boschia).

3. *Marchantieæ* (*a*, Astroporæ; *b*, Operculatæ; *c*, Targionieæ; *d*, Compositæ).

Just as the Corsinieæ may be regarded as a stage towards the development of the Compositæ, so a form similar to *Monoclea* is probably the starting-point for the thallose Jungermannieæ.

The difficult question of the comparison of the growth of the embryo in the Hepaticæ and in the Bryineæ is discussed at length.

## Fungi.

**Nomenclature of Discomycetes.***—G. Winter points out the great difficulty of recognizing the larger Ascomycetes, especially the Discomycetes, from published descriptions; partly from these being often descriptions of individual specimens rather than of species or even varieties; partly from their often being taken from immature specimens, in which the form of the spores and other adult characters have not yet appeared. Dr. Winter proposes that Cooke's 'Mycographia,' though not without faults, should be taken as the uniform authority for the nomenclature of the larger Discomycetes, and gives some examples in which he thinks the ordinary nomenclature requires rectification.

**Vegetative Budding of Pistillaria pusilla.**†—On a decaying vine-leaf K. Mika obtained a quantity of this fungus, in which abundance of fresh mycelium was being formed, not from the spores, but directly from the fructification, a phenomenon which the author considers comparable to the vegetative budding observed by de Bary and Farlow in ferns, by Stahl and Pringsheim in mosses, and by Brefeld in several fungi. In specimens in which the basidia were already nearly fully developed, all the cells of the fructification, and especially the basidia, budded very freely in the course of a day, producing new mycelia, which differed in no respect from those produced in the ordinary way by the germination of spores. The same occurred in cultures into which young specimens of the fungus were introduced. In all those cultures in which the budding took place, the result was the development of filaments on which new fructifications were formed, which arrived at full maturity, but without manifesting any trace of sexual organs.

**Structure and Germination of Sorosporium.**‡—R. Pirotta has followed the life-history of *Sorosporium* (?) *primulicola*, parasitic on the capsule of *Primula officinalis*, of which he gives a full description. If the distinction between the two genera *Urocystis* and *Sorosporium* is made to depend on the mode of development of the spores, this fungus must be placed in the latter genus. In *Urocystis* the central spores originate on the sporiferous branches of the mycelium which curve in a spiral manner; the peripheral spores from the mycelial filaments which at a later period surround the spiral. In *Sorosporium*

* Hedwigia, xx. (1881) pp. 65–72.

† Magyar Növ. Lapok, iv. (1880) No. 48.

‡ Nuov. Giorn. Bot. Ital., xiii. (1881) pp. 235–40 (1 pl.).

the sporiferous mycelial filaments interlace, forming the glomeruli, in which the spores develope from the centre towards the periphery. The mode of germination of the spores resembles that of *Tilletia*, of *Entyloma*, and especially of *Urocystis*.

The author considers that the question whether *Sorosporium* ought to constitute an independent genus, or whether it ought to be united with *Urocystis*, must remain unsettled until more is known about the germination of the spores of the other species of the genus.

**New Disease of Birds.***—Dr. Koester describes a new disease which has recently attacked hundreds of birds, chiefly hens and turkeys, in the neighbourhood of Cologne. It manifests itself as a kind of diphtheria, attacking the mucous membrane of the organs of respiration and digestion. In the excreted matter were found immense quantities of a micrococcus, grouped in colonies or distributed irregularly.

**Chemical Composition of Moulds.**†—N. Sieber has analyzed moulds grown on different substrata, the nutrient fluid consisting in the one case of sugar and gelatine, in the other case of sugar and sal-ammoniac; free phosphoric acid being added in both cases to prevent the development of Schizomycetes. The first contained 20 per cent. sugar and 70 per cent. gelatine; the latter 48 per cent. sugar and 8 per cent. sal-ammoniac. The following were the results:—

| | (1) | (2) |
|---|---|---|
| Soluble in ether .. .. | 18·70 per cent. .. | 11·19 per cent. |
| Soluble in alcohol .. .. | 6·87 ,, .. | 6·87 ,, |
| Ash .. .. .. .. .. .. | 4·89 ,, .. | 0·73 ,, |
| Albumen .. .. .. .. | 29·88 ,, .. | 28·95 ,, |
| Cellulose .. .. .. .. | 39·66 ,, .. | 55·77 ,, |

The moulds grown on sugar and gelatine contain therefore a considerably larger amount of ash and of substances soluble in ether, and a much smaller proportion of cellulose than those grown on sugar and sal-ammoniac.

**Phenomena of Growth in the Mucorini.**‡—The erect growth of the fructifying stem of *Phycomyces*, while the mycelium penetrates the substratum, has been attributed by Sachs to their different relations to the moisture of the air; by Van Tieghem, to a property which he calls "somatotropism," or the influence of the mass of the substratum. In order to determine this question Wortmann took spores of *Phycomyces nitens*, placing them on a piece of bread on a plate and moistening them; a bell-glass was now placed over the whole, and covered with a cylinder of blackened pasteboard. In three or four days fertile branches had appeared 1–2 cm. in height: one of these was made to grow through a minute opening in the centre of a glass plate, and a piece of pasteboard saturated with water placed near it. After only a few hours it was obvious that the fertile branch had

* Verhandl. naturh. Ver. preuss. Rheinlande u. Westf., xxxvii. (1880) pp. 8–9. See Bot. Centralbl., vii. (1881) p. 85.
† Journ. prakt. Chem., xxiii. (1881) p. 412.
‡ Bot. Ztg., xxxix. (1881) pp. 368–74, 383–7.

drawn away from the moist surface, sometimes by an angle of as much as 90°. If, on the other hand, the piece of pasteboard was quite dry, not the least curvature was observed. The author therefore attributes the erect growth of the fertile branch of *Phycomyces* to its effort to remove itself from the moist substratum.

The curvatures of growth in the stolons of *Mucor stolonifer* (grown on gelatine, the development on bread being too luxuriant) were found by Wortmann to be due to a peculiar constant but irregular nutation, which brings their apices into contact with some solid body, their irritability then giving rise to the production of rhizoids and fertile branches. There was not the least evidence that the mass of the substratum exercises an attracting influence on the stolons.

**Microscopical Organisms in the Intestinal Canals.***—Dr. D. D. Cunningham gives a full account of his investigations on organisms in the intestinal canals, which have led him to the following, among other conclusions: (1) Special parasitic forms may be specially associated with particular forms of disease without holding any causal relation to them. (2) In many choleraic excreta monadic, amœbal, and sporoid bodies are all abundant; but they are all developmental forms of one *Protomyxomyces coprinarius*, which only attains its full development outside the body. (3) The immature forms are "normal inmates" of the digestive canal of some of the lower animals, and in man they are found both in health and disease. (4) "The abnormal conditions" of the intestinal contents in certain diseases allow of their rapid multiplication. (5) The introduction of these reproductive elements, which, *per se*, seem quite innocuous, is through the medium of the air, at any rate mainly.

**Fungi of Diseases of the Teeth.**†—A. Weil considers the cause of decay of the teeth, whether external or internal, to be the Schizomycete *Leptothrix buccalis*, the mode of entry and propagation, and the life-history of which he follows out in detail. The acids which occur in the mouth, especially lactic acid, while they may greatly promote the decay, cannot give rise to it. The *Leptothrix* can be recognized readily by its iodine reaction. The author considers further that in many cases disease of various parts of the body can be distinctly traced to morbid products from the mouth and teeth. Other observers had already traced a connection between decayed teeth and septic abscesses, in which were found a fungus similar to that which occurs in diseased teeth.

**Bacillus of Leprosy.**‡—In pursuance of the investigations of Hansen § and others as to the cause of leprosy, and to determine the still undecided question whether it is due to heredity or to contagion, Neisser has undertaken a fresh inquiry as to the nature of leprosy, his material being obtained from a large number of subjects

* Quart. Journ. Micr. Sci., xxi. (1881) pp. 234–91.

† 'Zur Aetiologie der Infectionskrankheiten,' i. (1881) pp. 18–198. See Bot. Centralbl. vi. (1881) p. 266.

‡ JB. Schles. Ges. f. vaterl. Cultur, lvii. (1880) p. 65. See Bot. Centralbl. vi. (1881) p. 379.

§ See this Journal, iii. (1880) p. 310.

in Norway. In all the fourteen preparations brought home, obtained from the liver, spleen, testicles, lymph-glands, and other parts, with a $\frac{1}{12}$ Zeiss's oil-immersion objective, he found abundance of bacilli.

The bacilli had the form of small slender rods, with a length about half the diameter of a red human blood-corpuscle, and about four times as long as broad. They approach most nearly the bacilli connected with the septicæmia of the mouse, but are not so fine. They are invisible in uncoloured sections, but beautifully seen when tinctured with fuchsin and gentian-violet. Their relative position and distribution vary greatly according to the part where they are found. They lie either two or three behind one another, apparently forming a long sometimes curved thread; or six or seven lie parallel to one another; or large numbers are associated in all directions into a confused mass, which is only with difficulty resolved into its elements. At a later stage of the leprosy, the rods break up into granules; but whether these are the result of disintegration, or must be regarded as spores, is doubtful. The bacilli were found in greatest quantities in the skin; next to that in the testicles; also in the spleen and liver; they were found in the marginal parts of the lymph-canals; the kidneys were free from them.

These bacilli are regarded by Neisser as the primary cause or contagium of leprosy. He was led to this conclusion by their constant occurrence, their uniform form and structure; and by the fact that, with the exception of the micrococci always present in the epidermis, they were the only bacterial form observed, and were found only where a pathological process was already developed or was commencing.

**Vegetable Ferments and the Action of certain Poisons on Vegetable Cells.***—In sequel to his observations on metastasis,† W. Detmer distinguishes the following four varieties in the action of various compounds on vegetable cells on the one hand, and on ferments on the other hand:—

1. Neither are the cells killed nor does the action of the ferment cease. To this case belongs the observation that young seedling peas grown in the dark continue to grow steadily, in contact with a 1 per cent. solution of grape-sugar, and that the presence of the latter does not interfere with the starch-transforming power of diastase in the mixture of starch-paste and malt-extract.

2. Not only are the cells killed, but the activity of the ferment is destroyed. Salicylic acid and atropin, both in a 2 per cent. solution, are very powerful poisons; also cupric sulphate in solutions of any concentration. These substances also destroy the activity of diastase.

3. The cells are killed, but the activity of the ferment is not destroyed. This is the effect of not too dilute solutions of sodium chloride, of 1 per cent. solution of carbolic acid, and of fluids which contain a very small quantity of an ethereal oil.

4. The cells are not killed, but the activity of the ferment is destroyed. Some peas which had been made to swell in a 4 per cent.

* SB. Jenaisch. Ges. f. Med. u. Naturw., Jan. 28, 1881. See Bot. Centralbl., vi. (1881) p. 186.

† See this Journal, *ante*, p. 770.

solution of phosphoric acid, germinated; while in a mixture of starch-paste and solution of diastase with 4 per cent. of that acid the ferment lost its activity.

Since, therefore, these various substances do not always act in the same way on living vegetable cells on the one hand, and on ferments on the other hand, the author concludes that the vital processes depend on quite other fundamental causes than on the presence of processes of fermentation.

The author confirms the observation of Nasse that the presence of carbonic acid promotes in a remarkable manner the process of fermentation.

### Algæ.

**Algological Notes.***—The second part of Bornet and Thuret's 'Notes algologiques' contains descriptions of a new species of *Monostroma* and of several new or little-known Florideæ, as *Ptilothamnium pluma* Thur., *Spondylothamnium multifidum* Ng., &c., &c. But it treats chiefly of the Nostochineæ, and contains an entire rearrangement of the species of *Nostoc* and *Scytonema.* The formation and development of the spores are described in numerous species of *Nostoc*, *Nodularia*, and *Glœotrichia*, and of the hormogonia in these forms, in *Scytonema*, *Lyngbya*, *Calothrix*, *Plectonema*, *Rivularia*, and *Isactis.* The most important processes are remarkably uniform within the family. The authors also give fuller descriptions than have hitherto been published of *Microchœte*, *Fischera*, *Hormactis*, and other genera. The last-named genus is interesting as uniting the characters of *Nostoc* and *Rivularia.* The plates are remarkably carefully and accurately executed.

**Sexual Reproduction of Phæosporeæ.**†—G. Berthold describes a process of conjugation in *Ectocarpus siliculosus* and *Scytosiphon lomentarium.* The swarmspores, which are found in plurilocular sporangia, were cultivated in a moist chamber. Some came to rest earlier than others, losing their cilia; these are female, otherwise completely resembling the male in both size and form. When come to rest, they exercise a powerful attraction on the male swarmspores, which move round them in a dense mass until one of them coalesces with the female; and the impregnated swarmspore clothes itself with a cell-wall. It is noteworthy that the female swarmspore is in a receptive condition only for a few minutes; if it is not impregnated during this time, it clothes itself with a cell-wall and germinates without impregnation. But the fertilized swarmspores germinate earlier than those that have not been fertilized. The male swarmspores which have not conjugated also come to rest and germinate; but the resulting individuals are weakly, and soon perish. The fertilized swarmspores gave rise to filaments which bore both plurilocular and unilocular sporangia, the latter being possibly the immediate result of impregnation.

In *Ectocarpus pusillus* and *Girardia sphacelarioides* the author

* Bornet, E., and Thuret, G., 'Notes algologiques.' Fasc. 2. (Paris, 1880.)

† MT. Zool. Station Neapel, ii. (1881) 1 pl. See Bot. Ztg., xxxix. (1881) p. 290.

failed to detect conjugation, all the swarmspores germinating without conjugation. He saw, however, a number of malformations, which may have been mistaken by Goebel for stages in this process.

**Red Colouring Matter of Chlorophyceæ.***—Dr. J. Rostafinski has examined the nature and properties of the red colour assumed by the spores, isospores, oospores, and zygospores of many Chlorophyceæ, when they pass into the resting state. With sulphuric acid it assumes a beautiful dark blue colour, which completely disappears on heating, after first changing to red.

This same reaction is displayed also by the chrysochinon $C_{18}H_{10}O_2$ discovered by Liebermann. The two substances also agree in being soluble in fuming nitric acid. The spectrum of a solution of chrysochinon shows an absorption-band in the red at A, while at the violet end a total absorption begins a little before D.

Favourable instances for the examination of the red pigment of Algæ occur in the oospores and antheridia of *Chara*, in *Chlamydomonas*, in *Hæmatococcus*, and in transitory states of *Phycopeltis*, *Mycoidea*, and *Trentepohlia*. The last was chosen by the author. On treating this with cold alcohol, the pigment was at once dissolved, which is not the case in other instances. The cells had then become almost colourless, containing only minute drops of a strongly refractive, orange-red substance, which manifested the sulphuric acid reaction, and were soluble in chloroform and hot alcohol. If the entire plant is boiled in hot alcohol, small flakes of an apparently crystalline nature separate on cooling. A microscopic examination shows that radiating star-shaped drops of a red resinous substance are united together by means of a golden-yellow mass. The precipitate can be separated by means of cold alcohol from the yellow substance. Only traces remain of the red pigment, but sufficient to impart a beautiful orange-ruby-red colour to the chloroform. The spectroscope shows a continuous absorption similar to that of chrysochinon, but also the distinct chlorophyll-band between C and D.

Extremely similar reactions are presented by the xanthin of yellow flowers, such as the petals of the wallflower.

All the red spores, &c., of the Chlorophyceæ spring from chlorophyllaceous cells, and develope into chlorophyllaceous cells. *Trentepohlia* also soon becomes green, even if kept in the dark, the green colouring-matter showing the characteristic absorption-bands of the spectrum of chlorophyll. From these facts Rostafinski concludes that the red pigment, which he calls *chlororufin*, is a reduced chlorophyll, the chlorophyll being a product of the oxidation of chlororufin. It is possibly identical with Millardet's solanorubin.

The author remarks, in conclusion, that the *Hæmatococcus* of the Alpine glaciers never turns green, the green colour frequently observed on tracts of snow being due to a *Chlamydomonas*.

**Studies on Vaucheria.**†—In this paper Professor O. Nordstedt first describes some new species of *Vaucheria* from Oeresund:

* SB. Krakauer Akad. Wiss., June 20, 1881. See Bot. Ztg., xxxix. (1881) p. 461.

† Bot. Notiser, 1879, pp. 177 (2 pls.); see Hedwigia, xix. (1880) p. 61.

*V. coronata* and *V. intermedia.* The second part contains observations on the *Vaucheriæ* of the Herbarium Agardhii. It is worthy of notice that the name *V. ornithocephala* Ag. is older than the uncertain name *V. sericea* Lyngb. The third part contains a synopsis of all the hitherto known European species of the genus *Vaucheria.*

**Parasitism of Chlorochytrium.***—G. Schaarschmidt has observed this alga in peculiar circumstances among a mass of diatoms that were preserved through the winter for examination. No trace of the alga was seen when they were first received, but it made its appearance in the spring in the remains of leaves of *Quercus cerris* which came with the water. The zoospores bored into these, and there formed the large irregular sacs of *Chlorochytrium Lemnæ*, which subsequently became free and vegetated. These phenomena throw great doubt on the parasitic nature of this alga, assumed by Cohn.†

**New Diatoms.**‡—In an account of all the diatoms found in sea-water from the coast of Messina, Count (Abbé) Castracane describes the following new species:—*Coscinodiscus irroratus*, *Cyclotella marginata*, *Synedra calva*, and *S. toxoneides.*

**Fossil Diatoms.**§—In the tertiary slates of Warnsdorf, in Bohemia, K. J. Taránek has found remains and impressions of a moss (*Fontinalis* sp. ?), among which were a number of diatoms. One of these, *Melosira arenaria*, still exists in Bohemia. It is in a very good state of preservation. On the inside of the shell is a yellowish-green mass, attached in lumps, which Taránek regards as protoplasm, or the endochrome-plates, or both together in an altered form.

**Periodical and Massive Appearance of Diatoms.**‖—P. Richter records a number of instances of the sudden appearance of immense quantities of diatoms, usually recurring with regularity at particular periods of the year. Among other species are mentioned *Achnanthidium lanceolatum*, causing a yellow scum on the water; *Cyclotella operculata*, producing a brown scum; *Diatoma elongata*, in brackish localities; *Campylodiscus noricus*, &c. &c.

**Homeocladia and Schizonema.**¶—After his discovery of the multiplication of *Podosphenia* by spores, Count (Abbé) Castracane has made various observations on these two genera of diatoms. *Homeocladia Martiana* he found in small tufts on stones, and distinctly saw the movement of the *Nitzschia* within the sheath. The sheaths have the faculty of shortening themselves by transverse wrinkling, caused, the author believes, by temporary exposure to the

* Magyar Növéntyani Lapok, v. (1881) p. 37. See Bot. Centralbl., vi. (1881) p. 333.
† See this Journal, *ante*, p. 801.
‡ Atti Accad. Pontif. Nuovi Lincei, xxxii., Jan. 25, 1880. See Bot. Centralbl., vi. (1881) p. 333.
§ SB. kön. böhm. Ges. Wiss. in Prag, 1880, pp. 284–91 (1 pl.). See Bot. Centralbl., vii. (1881) p. 1.
‖ Hedwigia, xx. (1881) pp. 81–4.
¶ Atti Accad. Pontif. Nuovi Lincei, xxxiii. (1880). See Bot. Centralbl., vi. (1881) p. 181.

air. Together with the *Nitzschia* he found a *Navicula*, which moved within the sheath, and which apparently could only have entered in the form of a spore, and have developed there.

In *Schizonema* he also observed the alternate forward and backward movement of *Naviculæ* within the sheath, single frustules escaping through a small opening at the apex, which widened to allow of their passage, and afterwards contracted, showing that the membrane of the sheath must be elastic and flexible. The author came to the conclusion that the sheath-apparatus served solely for the purpose of the multiplication of the *Naviculæ*, and that the name *Schizonema* ought to be applied, not to the sheath, but to each separate enclosed frustule. He concludes that the genera *Homeocladia*, *Berkeleya*, *Encyonema*, and *Dickiea* must be identified with *Nitzschia*, *Amphipleura*, *Cymbella*, and *Navicula*.

## MICROSCOPY.

### α. Instruments, Accessories, &c.

**Descriptions of New Microscopes.**—Some of our correspondents appear to be affronted because in the accounts which we give of new Microscopes we omit by far the larger part of the descriptions usually sent us.

We do this advisedly, as we invariably give a figure, which at once dispenses with any necessity for a full description of those parts which are seen at a glance on referring to the drawing. Whilst in a catalogue or a treatise intended to describe various leading types of Microscopes, full descriptions may properly be included, it can be of no value to the readers of this Journal to have such paragraphs as this attached to a woodcut :—

" The Microscope consists of a base A in the form of a horse-shoe, in which is inserted an upright pillar B. To this pillar is attached a bar C, which by means of the hinge D can be placed in any position from the vertical to the horizontal. This bar carries at its lower end a ring E, which holds on the one side a plane and on the other a concave mirror. F is the stage," &c. &c.

For the purposes of this Journal, all that can be required in addition to a woodcut is a reference to such points as are special to the particular form.

**Lacaze-Duthiers' Aquarium Microscope (Ross Tank Microscope).**—This (Fig. 203) was devised by Professor Lacaze-Duthiers for use in aquaria, or for examining vertical surfaces, and has been somewhat modified by M. Nachet since the first model of 1864.

A column upon a tripod supports an arm at the extremity of which is the Microscope-body, which can be adjusted to the object in two rectangular directions by the two screws seen on the edge of the "drum" through which the tube passes. The "drum" contains the sliding metal rings by means of which the rectangular motions are obtained. The focussing is by rack and pinion (milled head shown at the side of the tube). The Microscope can also be revolved on

FIG. 203.

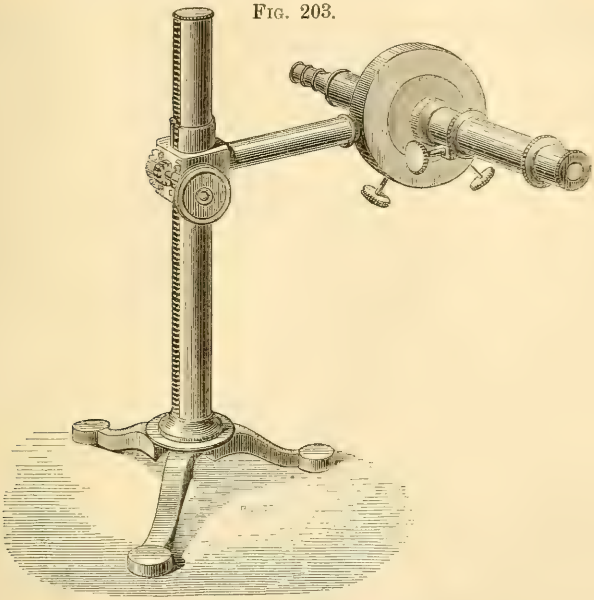
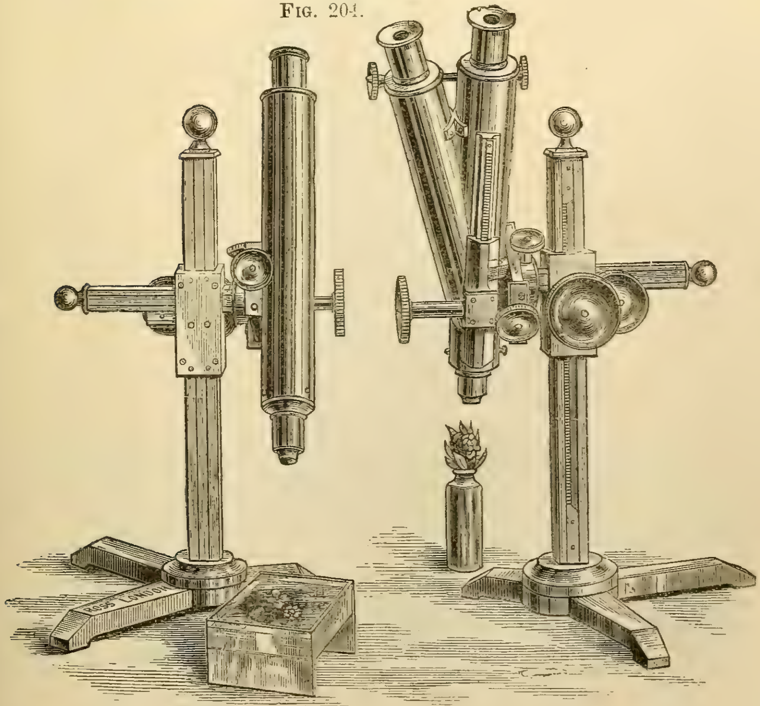


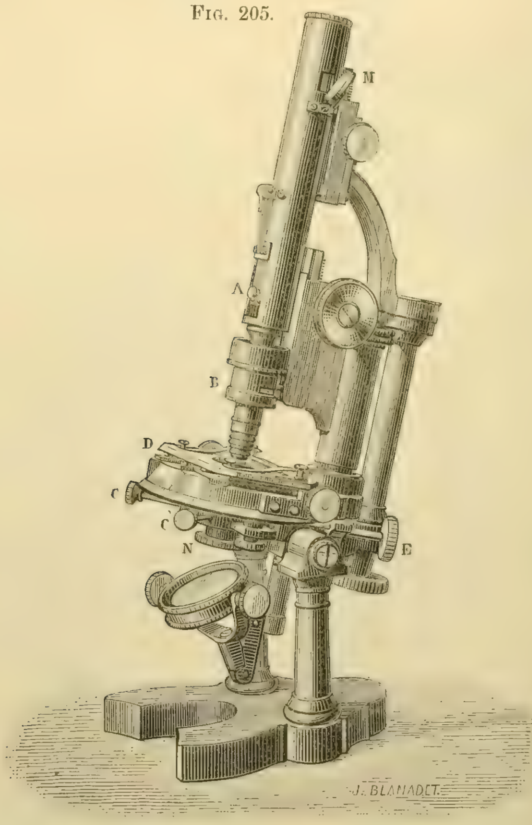
FIG. 204.



the horizontal arm, and vertical motion is provided by rackwork on the column. The rectangular motions give a moderate range within which a moving object can be kept in view.

The above arrangement is not, however, so convenient as the "Ross Tank (or "Aquarium and Physiological") Microscope," shown in Fig. 204, for examining large objects of all kinds. There is a vertical movement on the upright standard and lateral and inclining movements on the horizontal bar (the two former by rack and pinion). The two small milled heads at the side of the standard give rectangular motions to the body-tube of the Microscope, and the large one on the left is for focussing. A convenient table-stage with mirror (not shown in the figure) can be used with the instrument, or the table-tank shown under the monocular stand.

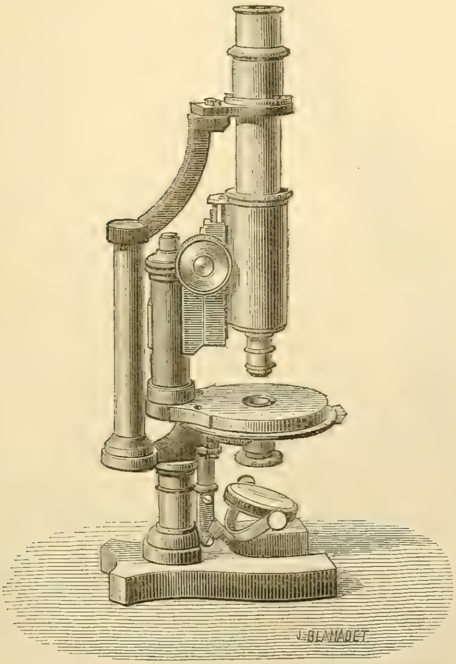
Fig. 205.




**Nachet's Petrographical Microscope.**—This instrument, described by M. Nachet at p. 227 of vol. iii., has been further elaborated by him, and is now issued in the form shown in Fig. 205.

The specialty of the instrument consists, it will be remembered, in attaching the eye-piece to a separate immovable arm, the body and stage rotating independently beneath it and above the fixed polarizer. This contrivance is retained in the new form, which has the following additions :—A small mirror M is placed immediately below the eye-piece, so as to illuminate the cross wires when the field is dark. The whole of the tube from A upwards is attached to the fixed arm, and is moved by a separate rack and pinion. The analyzer is inserted at A, and can be readily withdrawn when required. At B is a slit for the introduction of plates of quartz, &c. The stage is more elaborate, and has a traversing object-platform D rotating in the optic axis by the pinion E, or by hand. The polarizing prism N is not attached

FIG. 206.




to the stage, and can be centered by the screens C and C′. If it is desired to use the instrument as an Amici Microscope, a cone with converging lenses can be fitted into the end of the eye-piece tube, the latter being raised or lowered by the upper rack-and-pinion movement.

A smaller form on the same principle is shown in Fig. 206.

**Miller's Microscope with Telescopic Eye-piece.***—" In order to " view objects at any distance that may be required, and so obviate the

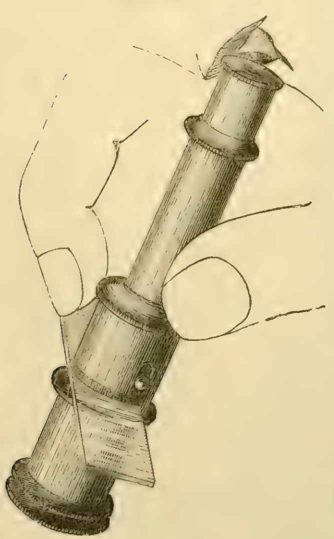
* Centr. Zeit. f. Opt. u. Mech., ii. See Zeitschr. f. Instrumentenk., i. (1881) p. 210.

"disturbing influence of the warmth of the observer's body," F. Miller substitutes for the ordinary microscopic eye-piece a telescope adjusted to parallel rays whilst the object is in the focus of the objective of the Microscope. The distance of the eye-piece of the telescope from the objective of the Microscope is immaterial; the image of the object always appears sharply defined.

**Salt's Pocket Microscope*** **(Swift-Brown Pocket Microscope).**—We take from the 'Lancet' the following description (modified to meet subsequent alterations) of a small pocket Microscope, by Salt and Son of Birmingham (Fig. 207) for the examination of urinary deposits, blood, &c.

"The stand and mirror hitherto deemed essential in all compound Microscopes are dispensed with. A lens is placed at the end of the Microscope, which when the instrument is held up to a window or lamp, concentrates sufficient light upon the slide to render all objects in the field distinctly visible. Even on a dull day in London we have found the illumination thus obtained amply sufficient. The Microscope is a compound achromatic one, furnished with a $\frac{1}{4}$-inch objective having a magnifying power of 120 diameters, and a sliding tube of short range for adjusting the focus. In using the instrument it is intended that a few drops of the suspected urine are placed between two small glass slides, which are then placed in a deep notch in the lower part of the Microscope. They are fixed *in situ* by a sliding tube [ordinarily pressed downwards by a spring, but which can be withdrawn within the upper tube (by the projections working in slits on either side) when it is desired to change the object]. The Microscope is then applied to the eye, as shown in the engraving, and the focus adjusted.

FIG. 207.



"It is an ingenious little instrument, very compact, measuring only five inches in length, and its case is scarcely bigger than that of a fair-sized urinometer. We can thoroughly commend it not only for convenience, but, when properly used, for efficiency also. It is well adapted for the examination of the blood; an excess of white corpuscles can be at once distinguished by its means. It is also, when properly employed, very useful for the examination of the urine; but used in the method recommended by Messrs. Salt, it is almost valueless for this purpose. It is true that if a urine were loaded with pus, this could no doubt be

* 'Lancet,' Jan. 29, 1881, pp. 188–9 (1 fig.).

readily discovered in the manner above described; but if the urine contained a few blood-corpuscles or casts, they could not be thus discovered. The film of liquid held between two [small-sized] glass slides by capillary attraction is so extremely thin that objects sparingly contained in the urine would not be discovered. If, however, a small cover-glass be used, and the movable tube be placed above the slide so as to clamp it from above instead of from below [this we understand to have been carried out in the newer form], and thus avoid pressing the cover-glass against the edge of the notch, a thicker film of liquid is examined, and the instrument answers very well. But its utility would be greatly increased if a plane mirror were fixed in a removable tube at the end of the instrument, so that it could be used in the upright posture as well as, if desired, in the horizontal. All practitioners know how desirable it often is, in examining a urinary deposit, to have a very thick film of liquid, and this is impossible unless the Microscope is vertical in position."

The difficulty we have found with this instrument is the great want of light, notwithstanding the condensing lens; and it cannot, we are bound to say, be compared with the small pocket Microscope designed and made by Mr. Swift and described by Professor G. T. Brown (Figs. 208, 209), which is more compact—3 × $\frac{3}{4}$ inch —and is far more convenient to use. It is provided with a mirror G, which can be removed when desired, and the piece which is seen projecting on the right enables full-sized slides to be used. It has also an achromatic condenser with diaphragm for oblique light as well as dark spots; and according to our experience, hardly leaves anything to be desired where an instrument is necessary which has to be in reality, and not in name only, a "pocket Microscope." (A is the main outer tube; D an inner tube carrying the objective and sliding within A for the coarse adjustment; E a third tube which supplies a fine adjustment. Within B is a spring tube which holds the slide C in position.)

Fig. 208.

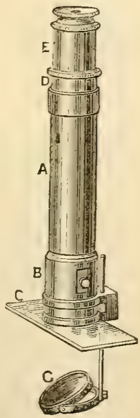
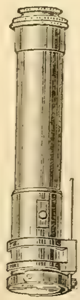


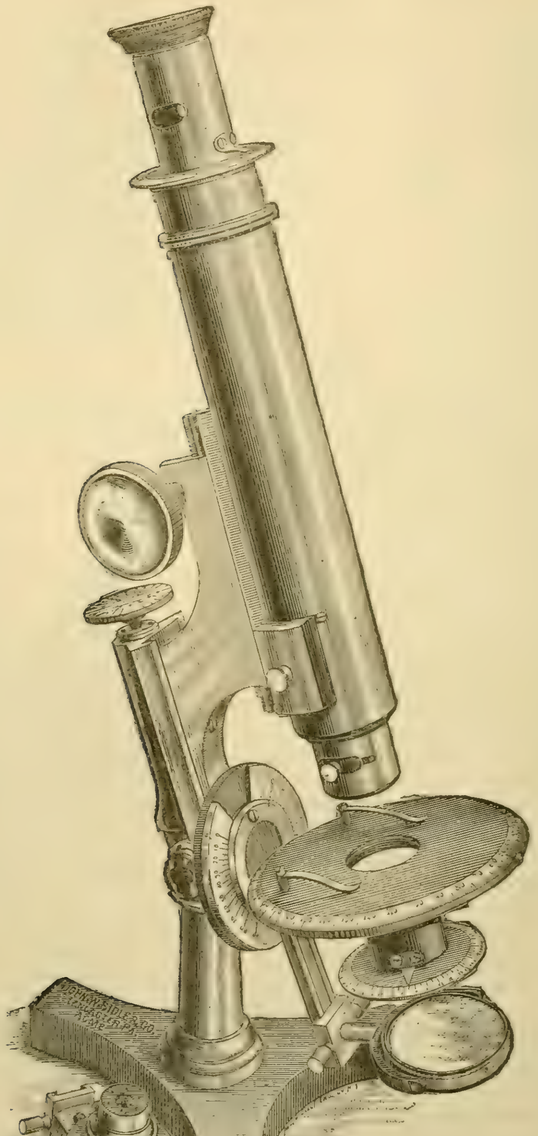

Fig. 209.



**Sidle's "Acme" Lithological Microscope.**—This (Fig. 210) is on the general plan of the "Acme" models (see vol. iii. (1880) p. 522, and *ante*, p. 657), but in lieu of the rotating stage-plate there is a permanent *rotating stage* graduated to degrees.

The *polarizer* is mounted on swinging arm to allow of being turned out of the way when not in use, and is furnished with a graduated circle and index, and a spring click showing when the prisms are crossed. It will receive a lens-system of extreme angle at its upper end, which, together with a corresponding system adaptable to the $1\frac{1}{4}$-inch screw in body-tube, serve to show the rings

Fig. 210.



and crosses in crystals. An *analyzer* and a *Klein's quartz-plate* are mounted in sliding boxes in the lower end of the body, each admitting of removal when their respective openings may be closed by sliding shutters provided for the purpose. An extra analyzer is mounted to slip over the eye-piece, and is furnished with a graduated disk with index.

For stauroscopic measurements a *double calcspar plate* is arranged to rotate between the analyzer and eye-lens.

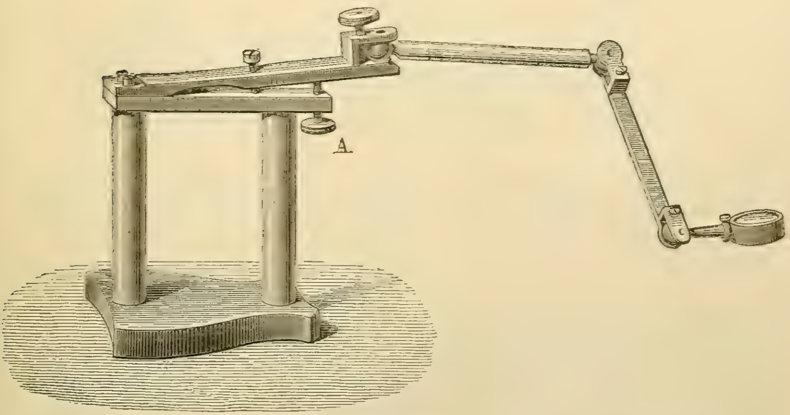
The eye-piece is also provided with *cross lines* ruled on glass.

The instrument can, of course, be readily converted into an ordinary monocular when not required to be used for its special purpose.

**Browning's Platyscopic Lenses.**—An addition has been made to this series of achromatic pocket lenses by a new one of lower power—magnifying 10 diameters—and larger field than has previously been made. The series now consists of lenses magnifying respectively 10, 15, 20, and 30 diameters.

**Nachet's Porte-loupe.**—This (Fig. 211) is substantially a modification of Strauss-Durckheim's lens-holder, the movements of the

Fig. 211.

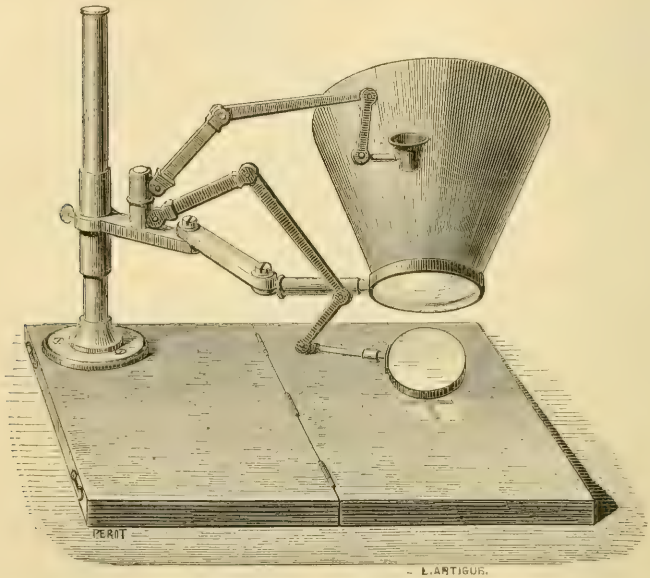



arms (which are articulated by balls held between claws) allowing the lens to be readily placed in every position. By the screw A, a fine adjustment is obtained.

**Lacaze-Duthiers' Porte-loupe.**—This (Fig. 212), also made by MM. Nachet, consists of three articulated arms attached to a horizontal support, and the latter to a standard, as shown in the figure, the whole of the arms together being movable vertically or horizontally. Two of the arms are fixed to a piece of tubing sliding on the horizontal

support, and carrying lenses of different powers, while the third has a bull's-eye condenser, to which can be fixed a funnel-shaped piece of blackened paper, to act as a screen. The box in which the apparatus packs serves, when opened flat, as a base.

Fig. 212.




The speciality of the apparatus appears to consist in the numerous articulations of the arms (which allow the lenses to be readily placed in any desired position), and its portability—35 cm. square by 7 cm. deep.

**Zeiss's Camera Lucida.**—The following is a translation of the revised directions for using this instrument (see *ante*, p. 818):—

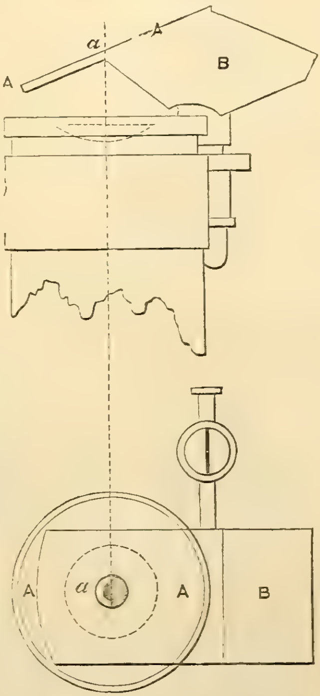
The apparatus having been attached to the Microscope by the "sprung" ring, turn back the prism round the vertical pin so as to allow the eye-piece to be inserted and the preparation adjusted. Afterwards the prism must be brought into the position indicated in Figs. 213 and 214 by the revolving motions round the vertical and horizontal pins, also by the horizontal and vertical sliding movements of the same pins, or where requisite by the ring as well.

As is shown by the figures, the circular opening *a* in the upper plate A A of the camera should be concentric with the eye-lens of the eye-piece. The small bright circle, which is seen above the eye-piece when the eye looks down upon it from some height in the direction of the axis of the Microscope, must then appear, approximately, *half* covered by the glass prism visible through the opening *a*. Seen from

the side, the plate A A must also be inclined to the axis of the Microscope, and the body B of the camera be placed as near as possible to the eye-piece.

Having made the adjustment approximately according to these directions, on looking down the Microscope and keeping the pupil of the eye exactly over the edge of the prism, there is seen within the field of view, and simultaneously with the microscopic image, a portion of the surface of the table, that part which lies near the foot of the instrument on the side of the prism B. If the camera has been put on with B to the right of the observer, the space which becomes visible is to the right of the Microscope; but if the camera is turned towards the front, as may be done when the light falls on the Microscope from one side, the space in front of the instrument will be projected into the field of view. Upon that part of the table which thus becomes visible must now be placed the drawing-paper in such a manner that it rests upon a support inclined towards the Microscope about 15° to 20°, so that the plane of the paper lies approximately parallel to the plate A A of the camera. If, after the camera has been adjusted as above directed, the field of view, on looking down the Microscope, appears obscured on either side by a glare of colour; or if the drawing surface is only visible in a part of the field of view, the imperfection may be cured by turning the camera very slightly round the vertical or horizontal pin, testing it in one or other direction whilst looking through it.

FIGS. 213 AND 214.




Tighlmann's Cylinder-Diaphragms for the Vertical Illuminator. —The vertical illuminator is shown in Fig. 215 (actual size) with Mr. Tighlmann's cylinder-diaphragm. The diaphragm consists of a short piece of cylindrical tube, from which about one-third of the circle is cut out, made to slide at will as an outer jacket over the circular aperture through which the illuminating rays pass to the plate of glass which is adjusted (within the adapter) in the optic axis and inclined 45° so as to reflect the rays to the objective from above—the objective thus serving as illuminating lens. The square end of the sliding cylinder, passing variously over the circular aperture, cuts off larger or smaller segments of the opening either vertically

Fig. 216), or horizontally (Fig. 217), and two small apertures give additional facilities for varying the effects (Fig. 218). The apparatus was constructed for Mr. Tighlmann by Messrs. Queen, of Philadelphia, U.S.A., and can be commended for its simplicity. The milling on the moving cylinder should, however, project much more, so as to present a better grip for the adjustment. The cylinder should also be lined with cloth to diminish the friction in moving. The vertical illuminator is seldom used except with high-power objectives, and it requires very delicate manipulation; unless, therefore, the diaphragm can be moved with a light touch, the image is apt to make bewildering excursions—especially when the apparatus is used with a Microscope focussing at the nose-piece. One of the principal considerations to be held in view in the application of diaphragms to illuminating devices should be to enable the observer to watch the effect produced during the actual movement of the diaphragm. The accurate discrimination of the more difficult images with high powers is so largely dependent on

FIG. 215.

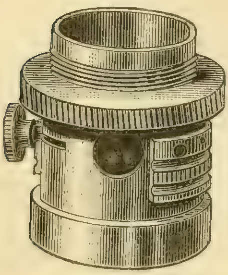


FIG. 216.

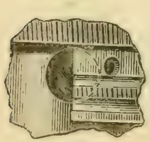


FIG. 217.

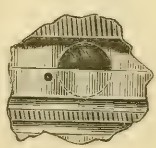
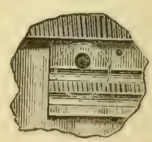


FIG. 218.



the convenient arrangement of the means for slightly varying the illumination, that we should consider any device defective in so far as it could not be controlled by the observer without removing his eye from the eye-piece.

Mr. Tighlmann's new diaphragm appears to us capable of developing the power of the vertical illuminator beyond the point hitherto attained.

**New Homogeneous-immersion 1-12-inch of 1·43 N. A.**—Mr. T. Powell has constructed a homogeneous-immersion $\frac{1}{12}$-inch objective of 1·43 N. A. without mounting the front lens on thin glass as described in this Journal, vol. iii. (1880) pp. 884 and 1050. The mounting of the front lens on a plate of glass of only ·003 in. thickness is obviously not a very secure method, whilst it necessitates special care in the use of the objective.

**Fluid for Homogeneous-immersion.**—Prof. Abbe has tested the chloral hydrate in crusts suggested (with glycerine) as a fluid for

homogeneous immersion by Mr. Basset,* but finds, on examination of various solutions of the substance by the refractometer, that it is not one for strictly homogeneous immersion, as it does not give as high a refractive index as oil of cedar-wood, even in its most concentrated form. Liquefied by the smallest possible quantity of glycerine into a very thick pap, it does not give a higher refractive index than 1·510 (at a temperature of 15° C.), which may therefore be taken very approximately as the true index of the *pure* chloral. Every practicable solution (even 10 or 20 parts to one of glycerine) must therefore have a lower refractive index than 1·510 and thus leave a slight defect of refraction, in comparison with ordinary crown (1·520), which is possessed by cedar-oil.

**Beck's Glass Friction-stage.**—This (Figs. 219 and 220) is a simple form of friction-stage for application to Student's Microscopes. The base-plate is circular and of brass with a deep rim to give

Fig. 219.

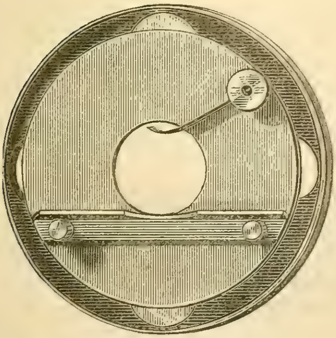
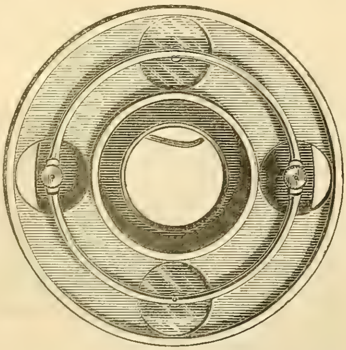


Fig. 220.



rigidity. In addition to the usual central opening there are four other circular openings of about $\frac{7}{8}$ inch in diameter, one in each quadrant. A polished glass plate is imbedded on the surface of the base-plate, having a central opening and two circular openings corresponding to those in one diameter of the base-plate. An upper brass plate, on which the object-slide is placed, has a piece of velvet cemented to its under surface, and it is held in contact with the glass by a strong wire ring beneath. Fig. 220 shows the under surface of the stage, and it will be seen that the upper brass plate (darkly shaded) is attached to the ring by milled-head screws passing through the right and left openings in the stage; the other two quadrants of the ring are provided with small ivory knobs which make friction-contact with the under surface of the glass plate (shown slightly shaded), through the other two openings in the base-plate. About $\frac{3}{4}$ of an inch of motion in all directions is thus allowed for the upper plate, and the movement is extremely smooth—the friction above is between

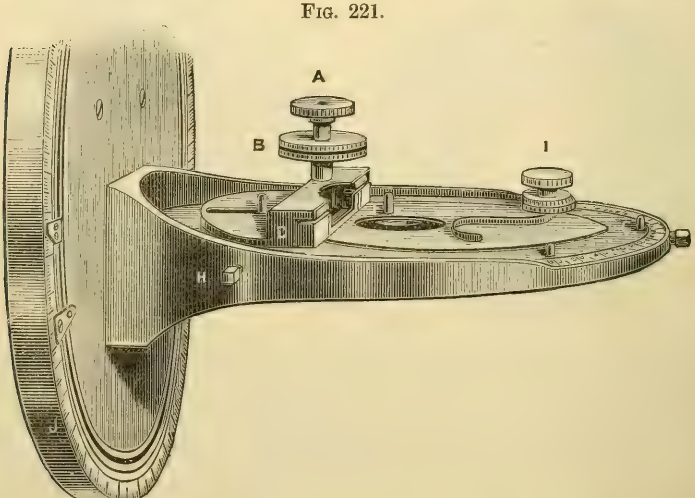
* See this Journal, *ante*, p. 123.

the velvet and the polished glass, and below between the ivory knobs and the glass surface. The friction can be somewhat increased by tightening the milled-head screws. An adjustable spring-clip keeps the object in position.

**Tolles's Mechanical Stage.**—Mr. Tolles has now further improved the stage described pp. 116–118 (Figs. 9 and 10). The improvements are comprised under four heads:—(1) The application of a rim or flange to the main stage-ring or support *above* the general plane of the stage. (2) The countersinking of the rotating stage-plate into the stage-ring. (3) The use of *one* plate only for the rectangular motions of the stage. (4) The union upon *one* axis of the milled heads controlling the rectangular motions.

(1) The upper surface of the main stage-ring H was formerly flat, and formed a bedding for the rotating plate C, the milled edge of the latter projecting slightly, for convenience of turning by the hand: a rim or flange is now applied to the ring H, outside the plate C, and is carried up to the shoulder by a gradually

FIG. 221.




increasing vertical thickness of metal, by which the rigidity of the stage is considerably added to. The shoulder forms a substantial attachment to the vertical disk which is fixed to the limb of the Microscope, and in which the substage and mirror slide laterally, concentrically with the object upon the stage (see Mr. Tolles' special form of traversing substage figured vol. iii. (1880) p. 521). Mr. Tolles' plan of making the rectangular and diagonal movements act completely *within* the circumference of the stage, has enabled him to strengthen the rim of the stage-ring *above* the general plane instead of *below* it; the inner part of this ring-support is flanged so that the rotating stage plate is countersunk flush with the thinnest part of

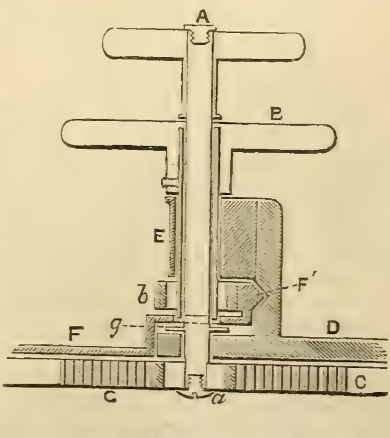
it—the perpendicular thickness of the working part of the stage, i. e. from the surface of the object-plate to the under surface of the ring which limits the free admission of oblique light, laterally or in front, is hardly more than one-eighth of an inch, and yet the rigidity is greater than in the previous model, where the thickness was about half an inch.

(2) As stated above, the rotating plate C, formerly rested on, and projected slightly beyond, the surface of the stage-ring H; it is now countersunk to the thinnest level of the stage-ring, and the graduations are advantageously made on the surface, where they can be more readily inspected. Small knobs are applied on the surface, near the edge, for convenience of turning by the hand.

(3) In the former model, the stage motions were obtained by means of two plates of German silver, each about 1-50th inch in thickness; the new model dispenses with the lower plate altogether (as first suggested by Mr. Wenham), the plate F, traversing horizontally in the box-fitting D, by means of a rackwork at its lower edge, and acted upon by the toothed pinion of the milled head B, whilst the vertical motion is given by the toothed pinion of the milled head A, gearing into a vertical slot rackwork in the rotating plate C,—the box D, with the pinions, and the plate F, moving together, all carried on a dove-tail plate sliding in a corresponding slot cut in the rotating plate, certain guide-pieces (like the peg shown behind D) serving to prevent lateral rocking.

(4) In the earlier model the rectangular motions were each controlled by a pinion and milled head on separate axes: now they are combined upon the *same* axis. The milled head A, attached to a solid pinion passing through the box D, is held beneath the rotating plate by a screw and friction-washer, and gives vertical motion, as explained under (3); the milled head B is attached to a hollow pinion (encircling the solid one) fitting in a ring fixed within D, and gives horizontal motion to the plate F, as noted under (3); the fittings of these pinions are so arranged that the motions are quite independent. In this last improvement (as applied to this form of stage) Mr. Tolles has been preceded by Mr. Wenham and Messrs. Watson.

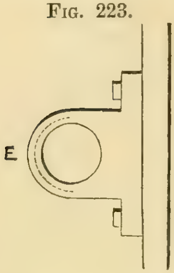
Fig. 222.




The mechanism of the stage-movements will be understood by reference to the section drawings (Figs. 222 and 223). In Fig. 222, A is a milled head attached to the inner arbor, communicating motion to the toothed pinion *a*, which works in the rack G attached to the revolving

plate C, and, travelling along the rack, gives vertical movement to the plate D, and also to the plate F on which the object-slide is placed. F and F′ are in one piece or connected. The pinion head B controls the hollow arbor surrounding A, and forms part of *b*, which gears into the toothed face of F′ and gives horizontal motion to F and F′—the upper plate (at F′) slides in a groove in the plate D bent upwards from this latter, and solid with it.

Fig. 223.




A, *a*, and D are made to work independently, and would be unaffected if all the mechanism of the horizontal motion were removed, i. e. there is *no friction* between the two arbors or parts. The milled head, arbor, and pinion A, are held firmly in D by the flange *g*, and by the pinion itself; the required tightening is given by the screw shown in the lower end of the arbor, and the pinion itself is shouldered on and clamped to the arbor.

Fig. 223 shows a top view of the box, or bearing, within which the hollow arbor E works, attached to the vertical moving plate D.

The special feature of the improved stage appears to be the gain in rigidity by the application of the rim or flange *above* the general plane —indeed it would now appear that the flexure, hitherto a serious drawback in all mechanical stages permitting a large range of obliquity of incidence beneath, is thus practically overcome. The new shaped rim does not in any way interfere with the rectangular and rotatory motions of the stage, whilst, instead of adding to the thickness of metal beneath the plane of the object, it has, on the contrary, enabled Mr. Tolles to reduce this perpendicular thickness to practically *nil.* The hemispherical immersion illuminator is applied to the under surface of the rotating plate C by a screw thread; the plane surface of the lens is then flush with the surface of the object-plate F, and the stage is so thin that upwards of 160° of the hemispherical surface is exposed beneath; dark field illumination could thus be obtained, even with Powell and Lealand's homogeneous-immersion $\frac{1}{8}$ of 1·47 N. A. (150° in crown glass).

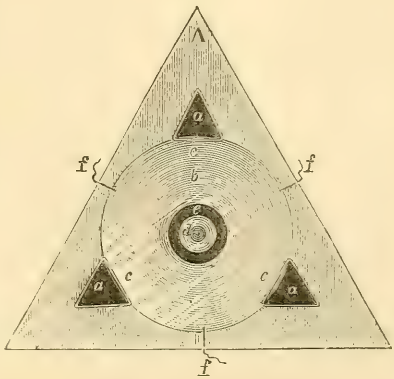
**Goodwin's Growing-slide.**—This slide was designed by Mr. W. Goodwin with the view of obtaining one in which the objects should be capable of being placed as much as possible under normal conditions as regards the supply of water, &c.

It consists (Fig. 224) of a triangular plate of glass A, the sides of which are the ordinary length of a slide (3 inches). Upon this are cemented three pieces of ebonite *a*, the inner surfaces of which are cut in a curve so as to allow a thin glass cover *b* to lie freely but closely between them. There is an indiarubber band *c* round each stop which projects a short distance across the cover, and prevents any movement of the latter when once placed in position. In the centre of the cover a small hole *d* is drilled, and round this hole is a metal ring *e*. Under the edges of the cover are placed three threads *f*.

The action of the slide is as follows:—Placed in a horizontal

position beneath a thread of soft cotton which is connected with a vessel of water, the water by capillary attraction and gravity runs down the cotton and falls drop by drop upon the centre of the cover, and quickly makes its way through the hole to the under side. When the space beneath the cover is full the water will then have reached the threads at the edge, and will so be drawn off. There is thus a constant flow of water supplied by the thread above and carried off by those at the edge of the slide.

FIG. 224.




Objects may be introduced into the slide through the hole in the cover, being first taken up in the dipping tube and allowed to flow slowly through the hole, and so under the cover.

A number of slides may be in operation at one time, it being possible to arrange as many as ten or a dozen round a base from which threads convey the water to each slide.

The slide was described by Mr. T. Charters White (at the last meeting of the Society *) as the best form which he had yet worked with.

**Diaphragms for Axial Condensers.**—At p. 667 it was stated that "no disposition of diaphragms has yet been applied to condensers used in the axial substage to enable us to regulate the *amount* of light without altering the *obliquity*."

FIG. 225.

With the simple diaphragms, however, shown in Fig. 225 (which were, we think, originally used by the Rev. J. B. Reade, with his "kettle-drum" illuminator) the obliquity of the light is unaltered when the upper diaphragm is rotated over the lower, or *vice versâ* (the lower indicated by dotted lines), while the amount is regulated axially at pleasure, from the maximum when the two slots coincide to an almost infinitesimal pencil when they are separated.

**New Dioptrical Formula.**†—The following is published by the French Academy on the report of Messrs. Fizeau, Jamin, and Cornu. The authority is Mr. C. V. Zenger.

"It is acknowledged that the abridged dioptric formulæ do not furnish results sufficiently exact for them to be employed in the construction of aplanatic and achromatic objectives.

* See *post*, p. 979. † Comptes Rendus, xciii. (1881) pp. 398–9.

Hence it is that all the celebrated opticians have had recourse to trigonometry for calculating the direction of the refracted rays, and I have done the same myself. But I have been able to formulate the results thus obtained, on account of the small difference in refraction which is found in the different kinds of glass, crown and flint, and have constructed tables which give in algebraical form the relation between the radii of curvature and the indices of refraction of the two media which enter into the construction of the objective, whether microscopic or telescopic.

The formula only contains the indices of refraction of the two media $n$ and $n'$, their relative dispersion $\frac{dn}{dn'}$, and some constants the value of which depends solely on the index of refraction of the least refractive medium. But what is more important is the fact that by the help of this formula the problem can be reversed, and we can find the indices of refraction and the dispersion necessary to render the double lens aplanatic and achromatic.

With the help of the tables I have constructed and the formula referred to, I have found that the best results are obtained when the following conditions are fulfilled.

1st. The dispersion should be such that $\frac{dn}{dn'} = 0 \cdot 5$, and this relation should be the same for all the partial dispersions from red to violet. Then the achromatism is perfect.

This condition can be realized by a mixture of aromatic substances, of which some react more on the red whilst the others, on the contrary, enlarge the violet part of the spectrum. By mixing two or three substances we can obtain the refraction and dispersion given by the formula for making the objective aplanatic and achromatic.

2nd. The index of refraction of the mixture should be $n' = 1 \cdot 63242$, for example, when the crown-glass used in the construction has an index $n = 1 \cdot 5296$. The formula gives the change in $n'$ for any other value of $n$.

3rd. All the radii are then identical. Hence I call the objective *symmetrical*, for the last radius $r_4 = \infty$, that is to say the last surface becomes a plane surface.

Any one can make his own telescope or Microscope without any calculation by taking a lens of quartz or crown-glass of any description and the mixture of aromatic bodies which gives to it a dispersion twice as great, or equal for all the rays of the spectrum.

We obtain the lens of the Microscope by reversing this lens, that is to say, the plane surface is placed on the side of the object.

The lens being corrected, it is combined with one or two other symmetrical lenses in the well-known mode, by which doublets and triplets are obtained perfectly aplanatic and achromatic; then, on going beyond the focus either way, no trace is found of the secondary spectrum.

The test objects which I have used are globules of mercury on a black ground, with sunlight, and the plate of M. Abbe of Jena, viz. a plate of silvered glass ruled with cross-lines in different directions.

A dazzling white is alone seen on a black ground, without the slightest trace of the colours of the secondary spectrum.

I consider that this is the method to be followed to solve the problem of absolute achromatism of objectives both for the telescope and the Microscope."

**Refractive Indices of Optical Glass.***—A table of refractive indices has recently been published under the heading of "Fraunhofer's Table of Refractive Indices," in which the following are the figures given for crown and flint glass for the lines C and G:—

| | | |
|---|---|---|
| *Crown:—* | | |
| Chance's soft | 1·5119 | 1·5263 |
| " hard | 1·5146 | 1·5280 |
| No. 13 | 1·5253 | 1·5399 |
| No. 9 | 1·5268 | 1·5416 |
| M. | 1·5559 | 1·5736 |
| *Flint:—* | | |
| Chance's light | 1·5700 | 1·5922 |
| No. 3 | 1·6038 | 1·6308 |
| Chance's dense | 1·6175 | 1·6453 |
| No. 30 | 1·6255 | 1·6554 |
| No. 23 | 1·6284 | 1·6588 |
| No. 13 | 1·6297 | 1·6603 |

These figures, however, require considerable supplementing, as in the present day glass is used for optical purposes, notably by Zeiss for microscope objectives, the index of which far exceeds anything given in the above table, being as high as 1·8017 for flint † for the D line. The flint is not perfectly white but slightly yellowish, which is not, however, perceptible in the small pieces used for the lenses of microscope objectives. We believe also that Messrs. Chance make a double-extra-dense flint of 1·71–1·72 index.

**Fine Rulings.**—We noted in vol. iii. (1880) p. 891 and *ante* p. 544, the alleged issue of rulings on glass of an almost fabulous degree of fineness. Mr. Fasoldt now writes ‡ as follows:—

"There seems to be some misapprehension in regard to my claims for fine ruling up to 10,000,000 lines per inch. The truth is, I have never claimed to rule that figure. I believe I once communicated the fact that my ruling-engine had an index capacity of 10,000,000, but it was necessary to arrange it thus in order to facilitate the subdivision in the lower figures.

"I have ruled plates up to 1,000,000 lines to the inch, one of which was purchased by the U. S. Government at Washington. These plates show lines truly and fairly ruled, as far as lenses are able to resolve, and above this point the spectral appearance of the bands in regular succeeding colours (when examined as an opaque object) shows, beyond doubt, that each band contains fairly ruled lines up to the 1,000,000 band.

"Dr. Ward seems to think that the simple setting of the register

* Engl. Mech., xxxiv. (1881) p. 56. † As low as 1·5017 for crown.
‡ Amer. Journ. Micr., vi. (1881) p. 163.

of a ruling-engine to the $\frac{1}{10}$ or $\frac{1}{10000000}$ of an inch, is all that is required to produce a ruling. I know that very many other conditions must be satisfied to produce perfect rulings.

"I do not believe that I will ever attempt to rule higher than 1,000,000 lines per inch, as from my practical experience and judgment I have concluded that that is the limit of ruling."

Whether 1,000,000 lines to an inch have really been ruled must remain an unsolved problem, for, as Prof. Helmholtz has shown, that number is very far beyond the limit of resolution.

### β. Collecting, Mounting, and Examining Objects, &c.

**Koch's New Method of Pure Cultivation of Bacteria.***—During the recent meeting of the International Medical Congress Dr. Koch explained the methods he had adopted in his researches into the relation of Bacteria to disease, and amongst them was a new and simple method of obtaining pure cultivations of the species of Bacteria, which Prof. Lankester considers to be "likely to mark altogether a new era in the study of the relations of Bacteria to certain diseases," and the determination of what effects are due to one species of Bacterium and what to another. To effect the separation of species in a mixture, Mr. Lister employed a method of dilution and division,† using a *fluid* as the nutrient medium of cultivation, as hitherto has been the almost universal practice. This method is tedious and liable to failure owing to the great care necessary to ensure and maintain sterilization of the cultivation fluid whilst exposed for the purpose of inoculation, and again for further examination. Dr. Koch's new method of cultivation essentially consists in the substitution of a *solid* for a fluid medium, and he was led to it by the use of the method, known to all mycologists, of cultivation upon slices of potato or beet-root. It is readily observed, when slices of boiled potato are exposed in a damp condition to the atmosphere, that the surface of the slice becomes the seat of development of various Bacteria and of moulds, the spores of which fall from the atmosphere on to the exposed slice. A fact which struck Dr. Koch as of importance in reference to the slices of potato was this, that the various spores falling on to it remain where they fall, and from the spot where each spore or germ originally fell it proceeds to multiply, producing around it a symmetrical hemispherical growth of perfect purity. In fact, owing to the solid character of the nourishing support, the germs and spores cannot get mixed as they do in a liquid; each remains distinct from its neighbour, even though in very close proximity, and without any trouble from the resulting growth which proceeds in a day or two from each germ, new and perfectly pure cultivations may be started in suitable sterilized fluids.

Dr. Koch's method consists in substituting for the potato slice a layer of gelatine, which is so saturated with water as just to become solid on cooling. The gelatine liquid is readily sterilized by boiling, and into it can be introduced either Pasteur's salts, peptones, blood-

* Quart. Journ. Micr. Sci., xxi. (1881) pp. 651–4. † Ibid., xviii. p. 191.

serum, or other nutrient material required by one or other species of Bacterium. The gelatine-medium thus prepared may be kept in a tube and a cultivation thus carried on upon its surface, or (and this is its principal use) it may be spread when liquid on a microscope object-slide and allowed to cool. Then such a gelatine plate may be inoculated by touching its surface with material containing the Bacteria which it is desired to study. The plate is readily protected from the access of accidental atmospheric germs, and maintained at such temperature and degree of moisture (by a glass shade) as the experimenter may desire. The main point of advantage is this, that the point of inoculation on the surface of the gelatine can, owing to its transparency, be readily examined with the highest powers of the Microscope, and the growth of the Bacteria followed; whilst further, owing to the fact that the medium in which the growth takes place is solid, no mixture of the different kinds which may be present occurs, but each Bacterium produces around it a little spherical nest of its own kind. From these nests, with a sterilized needle-point, individuals can be removed to start new pure cultivations.

But it is obvious that, if the original point of inoculation was very minute, there is no danger of any accidental contamination from atmospheric germs, for these are not likely to fall on the identical spot no bigger than the puncture of a needle's point, where the experimental culture is going on. As a matter of fact, where they fall on to the gelatine there they remain and grow, and fifty such accidental spores may fall on to the gelatine plate without in the least interfering with the purity of the experimental culture.

There is yet further a very simple device which enables Dr. Koch to use this gelatine surface as a means of "spacing" and dividing the various species in a mixture of Bacteria. He dips a sterilized needle into such a mixture, and then makes a long shallow streak with the needle's point upon the surface of the gelatine. The Bacteria which were adhering to the needle's point are in this way dropped at intervals along the streak, some nearer, some further apart, but all (with rare exceptions) in such a way that their subsequent growth keeps clear of that of a neighbour, and can, with the aid of a low power or even without any Microscope, be visited by a sterilized needle-point, and thus used to start on another gelatine plate a perfectly pure cultivation.

"It is only by such monosporous cultivations," writes Professor Lankester, "that we can arrive at solid conclusions in reference to the forms and activities of the Bacteria, e.g. as to whether one form can give rise to progeny of another form when its food and conditions of growth are changed, and again, as to whether special fermentative powers can be lost or acquired in the course of generations derived from one parent germ, but subjected to different conditions as to food, temperature, and oxygen. The method of gelatine cultivation devised by Dr. Koch places the means of following out these inquiries in the hands of every careful microscopist. Such methods as Lister's were too troublesome and too difficult for general and widespread application; but now that monosporous cultivation of Bacteria has been rendered a comparatively simple and certain affair, we may expect

immediate and immense advances in our knowledge of the whole series of phenomena to which the Bacteria are related.

"Amongst problems which require immediate investigation by the new method are the distinctive properties of the various kinds of Bacteria which may infest the wounds of surgical practice, and their specific susceptibility to the destructive influence of carbolic acid and other antiseptics; further, the possibility of isolating a specific Bacterium in contagious diseases not yet investigated; and (of great physiological interest) the isolation and investigation of the properties of the specific Bacterium of the ammoniacal fermentation of urine."

A remarkable negative result obtained by Dr. Koch, so far as his experiments with the new method of monosporous culture have yet extended, is, that there is no transition of forms amongst, at any rate, the pathogenous Bacteria—a Micrococcus produces Micrococci, and no other form; a Bacillus produces only Bacilli; a biscuit-shaped form (Bacterium proper) only biscuit-shaped forms; a Spirillum only Spirilla. Moreover, the *facies* of the discoidal or spherical mass formed by a growth, as seen with a low power, excavating its way in the gelatine, is characteristic of species, so that a practised observer can in some cases recognize a particular Bacillus or Micrococcus by the naked-eye appearance of the growth alone, or, at any rate, without actually observing the individual units of the growth.

Sterilization of Animal and Vegetable Liquids.*—Pasteur has proposed to render sterile liquids infested with Bacteria by filtration through plaster of Paris, and MM. P. Miquel and L. Benoist have devised a simple method for working out this process. The neck of a flask is drawn out, and the part above the contraction is sealed by a plug of plaster of Paris and asbestos, and immediately below the contraction a fine capillary tube is drawn out at the side. The apparatus is then dried for a week or two at 40° C., and finally heated to 170°, in order completely to destroy the germs on the sides of the flask and on the plug. When the flask is cooling, the capillary point is introduced under perfectly sterilized water, and on breaking it off, 40–50 c.c. of water pass up into the flask. The liquid is then boiled to expel the air completely from the flask, and the point is resealed, while at the same time the plug is introduced into the infested liquid. On cooling, the liquid passes into and fills the flask. The authors draw attention to various precautions which are necessary to ensure success.

Hardening the Spinal Cord.†—The following method of hardening the spinal cord for microscopic sections has been highly recommended by Dr. M. Debove:—

Place the cord in a 4 per cent. solution of bichromate of ammonia for three weeks, then in a solution of phenic gum for three days and for three days more in alcohol. Sections may then be cut with great facility. They should be placed in water to prevent curling. They are then immersed in a saturated solution of picric acid for

* Bull. Soc. Chim., xxxv. (1881) pp. 552–7. See Journ. Chem. Soc. (Abstr.), xl. (1881) p. 835.

† Archives de Neurologie. See Science, ii. (1881) p. 482.

twenty-four hours, and coloured with carmine for about twenty minutes, the picric acid acting as a mordant.

**Transferring Sections from Alcohol to another fluid.** * — In order to avoid shrinking in transferring from absolute alcohol into ethereal oil, or chloroform † (from a lighter into a denser fluid), Dr. W. Giesbrecht recommends that a quantity of absolute alcohol should be poured into a glass vessel, and by means of a pipette let the oil or chloroform run underneath it, so that the two fluids may lie one under the other; then drop the object into the alcohol, and take away all the superfluous alcohol. When the objects have sunk to the bottom of the vessel, the exchange of fluids is completed. Many objects, however, will not sink down in the dense chloroform; but this inconvenience can be got rid of by a suitable addition to the chloroform (e. g. sulphuric ether, &c.). In other cases the disappearance of those figures of refracted light, which always make their appearance when two fluids of different refractive powers mix, must serve to indicate the completion of the exchange. This is the most simple way to retard the exchange of fluids, and so avoid the cause of shrinking.

**Imbedding in Paraffin and Freeing the Sections.** ‡ — Dr. Giesbrecht also describes the process which he has found advantageous for imbedding the object after its transfer, as above described, from absolute alcohol into chloroform, which of all solvents of paraffin § gives the best results, and is most easily evaporated. Some sulphuric ether should be added to prevent the object swimming, and the chloroform, with the object, is then slowly warmed to the temperature of the melting-point of paraffin; whilst this is being done small pieces of paraffin are put in gradually. Here, too, shrinking is avoided, by making the displacement of the chloroform by the paraffin take place very gradually. It is completed when no more air-bubbles rise from the object.

For fixing the section with certainty and facility during the removal of the paraffin, a stock of slides should be provided, the centres of which are overlaid with a *very thin* and *very uniform* layer of shellac. Such a layer is easily produced by dipping a pretty thick glass rod into a well-filtered and not too concentrated solution of brown shellac in absolute alcohol, and passing it lengthways over a slide *previously warmed*. Shellac as clear as possible will of course be chosen; the so-called white shellac cannot, unfortunately, be used, because it is not soluble in alcohol. Before commencing cutting, brush over the shellac layer *very thinly* with creosote, ‖ and then lay the section upon it with *as little paraffin as possible*. The slide, with the section, is afterwards exposed for about a quarter of an hour in a water

* Zool. Anzeig., iv. (1881) pp. 483–4.

† This applies also to transfers from water or alcohol into glycerine.

‡ Loc. cit.

§ A solution of very hard paraffin in an equal volume of chloroform keeps fluid with the warmth of the hand.

‖ Creosote dissolves both shellac and paraffin, hence its application in this case. Turpentine does not dissolve shellac.

bath to the temperature of the melting-point of the paraffin used, and allowed to cool. The creosote is then evaporated, and the section fixed so well by the shellac that turpentine can be let pass over it freely without displacing it. After covering with Canada balsam, the shellac-layer is no longer discernible, provided it was thin and uniform.

**Imbedding in Paraffin.***—Mr. E. L. Cheeseman, in cutting vegetable sections, makes a short paper tube the same size as the well-hole of the section cutter, by rolling a strip of paper round a cylinder; a cork is fitted to one end of the tube, and to the upper side of the cork is attached by cement or otherwise the specimen to be cut (previously hardened in alcohol, if necessary) in such a manner that it will stand upright in the centre of the tube. Fill the tube with melted paraffin, and when cold remove the paper, and there is a plug of paraffin enclosing the specimen. Several of these plugs should be made at a time, and kept in alcohol until wanted.

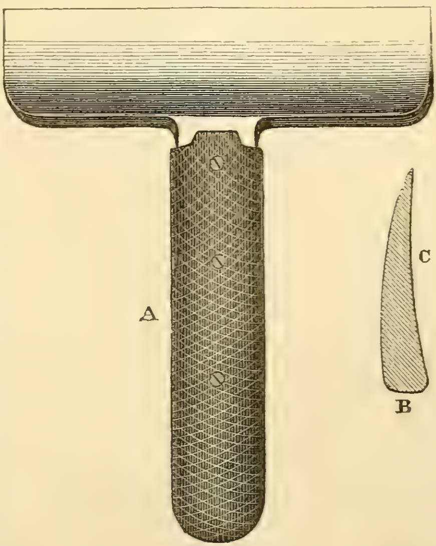
**Taylor's Freezing Microtome.**—At the last meeting of the American Association for the Advancement of Science, Mr. Thomas Taylor, Microscopist of the Department of Agriculture at Washington, presented a model of a new freezing microtome of his invention, which consists of a thin brass tube about $1\frac{1}{2}$ inch in length, by 1 inch in diameter, with a $\frac{1}{4}$-inch brass tube secured within the larger cylinder. This tube enters the bottom where it is secured, and proceeds to within a quarter of an inch of the inside surface of the top. To the outside open end of this tube a rubber tube is attached; the other end of the rubber tube is made to communicate with a freezing mixture composed of finely cut ice and salt in about equal proportions. The pail containing this mixture is placed over and about 15 inches higher than, the section-cutter. The object of this arrangement is to fill the brass cylinder with a freezing liquid, drained from the pail, and produced by the liquefying salt and ice, the temperature of which is about zero. On filling the cylinder with the liquid any object on the top of the cylinder becomes frozen in a short time, and may then be cut to any degree of thickness. In order to preserve the low degree of temperature in the cylinder, a second tube is secured in the cylinder to remove air and to keep up a constant current of the freezing liquid. This tube also enters the bottom of the cylinder, where it is fastened. It projects upward to within an eighth of an inch of the top, and has a diameter of about one-half of the supply tube. This microtome in other respects is arranged like the ordinary microtomes, used for ether or rhigoline.

**Waller's Section-knife for large Sections.**†—Dr. B. C. Waller recommends a knife, for service chiefly with the larger freezing microtomes, with wells 2 inches in diameter, and in making large sections. It consists (Fig. 226) of a blade $7\frac{1}{2}$ inches long, 2 inches broad, and $\frac{5}{16}$ of an inch in thickness at the back, set at right angles upon a stout

* Amer. Mon. Micr. Journ., ii. (1881) p. 114.
† Edinburgh Med. Journ., xxiv. pp. 893–5.

handle 10 inches long, formed by a prolongation of the metal of the blade, firmly riveted between two pieces of wood. It resembles a T, the horizontal part being the wood, and the vertical one the handle. The blade is thick and chisel-edged, to prevent bending into the well when pressed firmly upon the cutting-plate. When in use, the end of the handle is grasped by the right hand, while the little finger and adjacent palm of the open left hand are made to exercise steady pressure on the broad blade close to the handle. The breadth of the blade prevents the hand from coming into contact with the section when cut.

Fig. 226.




When a section is about to be made, the blade is placed in the ordinary manner upon that part of the cutting-plate nearest to the operator. The edge is then pressed firmly against the plane of the plate with the left hand, at an angle of about 45°, and the section shaved off by a rapid, steady, straightforward push of the edge through the tissue. By observing these directions the largest sections can be made with great rapidity, with perfect evenness, and with wonderful ease. In the figure, A is a general view, and B is the section of the blade, C being the edge which is held downwards in cutting.

It may be asked, If the section is made by a simple push or thrust, where is the necessity for a cutting edge $7\frac{1}{2}$ inches long? Why not use a broad knife at once? The reason for the extra length of blade is twofold: firstly, because, to prevent bending of the edge into the well, it is advisable to distribute the pressure upon those parts of the cutting-plate which lie to each side of it; and secondly, because for certain tissues a drawing, or rather an oblique pushing cut, is preferable to a straight thrust, and for such a method of cutting a considerable length of edge is requisite. In cutting nervous tissues, the knife should be slowly pushed through with a steady equable pressure, when, if properly hardened, they will curl themselves up on the back of the knife, and may then be transferred to a basin of water in the ordinary manner.

The author claims that by this knife large and perfect sections can be cut to almost any degree of thinness, with greater facility, rapidity, and certainty than with the ordinary pattern. The difficulty

in keeping the edge flat in the cutting-plate is entirely obviated, as the downward pressure is exercised with the whole left hand, instead of with the tips of the finger and thumb.

**Staining of Living Unicellular Organisms.***—K. Brandt finds hæmatoxylin and Bismarck-brown suitable colouring materials with which to stain Protozoa in the living state. For Amœbæ and Heliozoa a dilute solution of hæmatoxylin in water is allowed to act for a short time; in any case the process must be limited to an hour, as even Amœbæ succumb to a longer treatment. Pure water should then be allowed to replace the staining fluid. The nuclei are found stained pale violet. By this method the author has discovered nuclein in the form of numerous round granules in the endosarc of Amœbæ and *Proteus*, Leidy, measuring from $\frac{1}{1500}$ to $\frac{3}{1000}$ mm. in diameter; they have the same optical properties as the nuclei, and react chemically in the same way, and stain readily and deeply with hæmatoxylin. The bulk of extra-nuclear nuclein may be seen in old specimens to exceed that of the nucleus itself, and in young individuals exclusively to represent the nucleus. The author has been led by the remarkable appearance of the so-called nuclei to regard them as reproductive bodies, and to consider the nuclein granules as representing the nucleus proper, for the membrane enveloping the nuclei appears in this *Amœba* to consist of cellulose, it being insoluble in solution of caustic soda, but dissolving in ammonia-oxide of copper.

Hæmatoxylin at first produces no visible change in the liquid of the contractile vacuole; this later assumes a yellowish tint, and finally becomes brown shortly before death: the acid reaction of the liquid is thus proved. Bismarck-brown stains the nuclei of dead cells, but the only parts of Protozoa affected by it in the living state are the fatty granules and a peculiar mucous substance resembling cellulose. The solution should have a strength of either 1 to 3000 or 1 to 5000; it is best adapted for Heliozoa, Amœbæ, and Flagellata, which remain quite healthy even after staining for several hours, and when the parts above-mentioned have assumed a deep brown, if replaced in pure water; the colour is long retained by the fat-granules. Double-staining may be effected by first using Bismarck-brown for an hour, and then hæmatoxylin for a much shorter time; the protoplasm alone remains uncoloured. The difference in their colours shows which of the granules are fatty and which consist of nuclein. When death sets in, in consequence of this treatment, the nucleus becomes very deeply stained, and the protoplasm acquires some colour. The action of cyanine or quinolein blue, used in the proportion of 1 : 100,000 or 1 : 500,000, recommended by Certes for Infusoria and histological elements,† is essentially the same as that of Bismarck-brown. Certes finds that Infusoria also stain with Bismarck-brown.

**Klein's Cochineal Fluid.**‡—Dr. R. J. Harvey recently exhibited to the Dublin Microscopical Club specimens of cerebellar cortex,

* Biolog. Centralblatt, i. (1881) pp. 202–11.
† See *ante*, pp. 527 and 694.
‡ Ann. and Mag. Nat. Hist., viii. (1881) p. 232.

cerebral cortex, and gastric mucous membrane, stained with Klein's cochineal fluid. The preparation of and *modus operandi* with this fluid are exceedingly simple: 1 per cent. of alum and cochineal in distilled water are boiled to four-sevenths of the original volume; when cool, a few drops of carbolic acid are added, and the liquid filtered. Sections will stain well in three or four hours, but will not be injured if left twenty-four hours. They require nothing but washing in distilled water. The branching processes of Purkinje's cells in the cerebellum, the connection of the kite-shaped cells of the cerebral cortex, and the "chief" and "investing" cells of the gastric mucous membrane were rendered especially evident by this method.

**Purpurine for Staining Fœtal Vertebræ.*** — Dr. Harvey also showed a section of fœtal vertebræ stained with purpurine. All the effects for which double-staining had been so much recommended of late, in studying the process of ossification in cartilage, are brought out by this dye. The cartilage matrix remains unstained, the new territories of bone-substance assume a distinct though somewhat pale hue, while all the cells (cartilage-cells, bone-cells, osteoblasts, and marrow-cells) become brilliantly stained.

**Cements and Cementing.†**—Mr. C. E. Hanaman, after an experience of more than twelve years, during which he has used nearly every kind of cement that has been suggested in the journals and books published in England and America, has arrived at the conclusion that two, or at most three, cements are capable of ensuring the preservation of an object in any medium the microscopist will find it necessary to employ. These are gold-size (Windsor and Newton's), the ordinary dammar mounting medium, and possibly, for occasional use, the dammar medium to which a small proportion of a solution of rubber in naphtha has been added.

Dr. Seiler and others have directed the student to apply his cements in several coats, using great care in holding the brush, and as to the quantity of cement in the brush. The author saves himself much of the time required by such methods of manipulation, by putting on the cement in a broad band over the junction of the cover with the slide, and then, spinning the turntable as rapidly as possible, running the cement into a narrow band, in its proper place, by holding a knife-blade first on the slide and then on the cover, in such a manner as to cause the cement spread out by the brush to heap itself up into a narrow but perfect ring. One coating of cement thus put on is equal to three or four coats by the other method, while the polish of the ring far surpasses in perfection the brush-made ring.

If it is desired to colour the ring, instead of using anilin mixed with the cement, the more transparent of the water-colours are useful. The manner of their application is this: After the dried balsam or dammar has been thoroughly cleaned from the slide and cover, the preparation is placed on the turntable, and a narrow ring of the water-colour applied. This will dry quickly and look somewhat

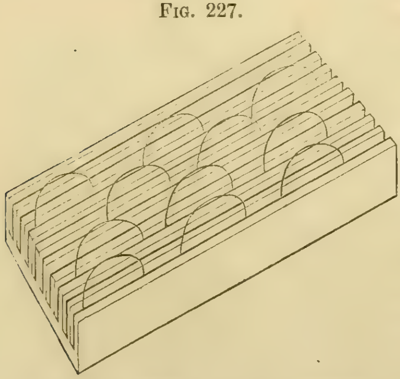
* Ann. and Mag. Nat. Hist., viii. (1881) p. 234.
† Amer. Mon. Micr. Journ., ii. (1881) pp. 143–4.

opaque. The dammar cement is then put on over the coloured ring as above directed, and it will be found that the result is equal in beauty to the celebrated shellac and anilin rings of Mr. Merriman, without the danger of the colours running in, as they often will do when anilin or any colour soluble in the cement is used. When glycerine or aqueous fluids are used, it is necessary to apply the dammar alone for a first coat, the water-colour being applied over this, and a final coat of gold-size or rubber cement over all. Windsor and Newton put up water-colours in little vials ready for use, under the name of "liquid water-colours," by the use of which the student may save himself the trouble of rubbing down the cake.

The centering of the cover may be quickly and accurately accomplished in the following manner:—The slide is placed in the jaws of the self-centering turntable, a very narrow ring of water-colour is made upon its surface with a finely pointed brush exactly the size of the cover-glass to be used. This will dry very quickly; if a number of slides are done at one time, the first will be dry by the time the third is done. The coloured ring being insoluble in any but water mediums, the object may be arranged on the slide in alcohol, oil of cloves, carbolic acid, balsam, or dammar, and it will be easy to see when the edge of the cover exactly coincides with the edge of the coloured ring. This ring will show through the transparent ring used for finishing, provided it be not covered by a broader ring of colour before the finishing ring of cement is applied, as suggested above. In any case it does not detract from the appearance of the slide.

From the fact that the glass slides are not perfect rectangles, it is necessary to place the same corners in the same clutches of the self-centering turntable every time a slide is manipulated on the table. The simplest way to do this is to mark one of the clutches with a cross, and similarly to mark with a file or writing diamond one corner of each slide while cleaning it.

Fig. 227.



**Preserving Cover-glasses.***—Mr. C. E. Hanaman keeps upon his work-table one or more grooved blocks like that shown in Fig. 227, in which cover-glasses that have been selected for immediate use are supported on their edges, and from which they can be easily taken by the forceps.

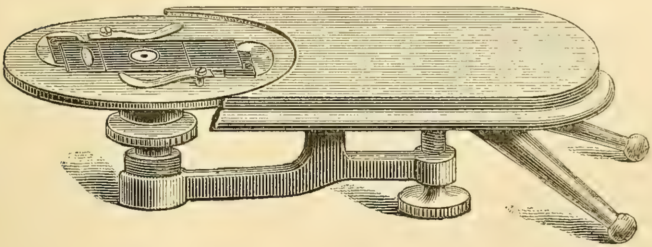
It is also convenient, when a number of covers have been cleaned, to keep them in drawers or boxes filled with narrow strips of new

* Amer. Mon. Micr. Journ., ii. (1881) pp. 142–3 (2 figs.).

white blotting-paper, between which the covers are placed on edge. This not only preserves them from breakage, and enables one to readily pick them out when wanted for use, but also facilitates the selection for special preparations of those of the most desirable thickness; for, by holding the drawer or box between the eye and the light, it is easy by comparison to select the thickest or thinnest cover, and thus, for all practical purposes, to do away with the trouble of measuring them.

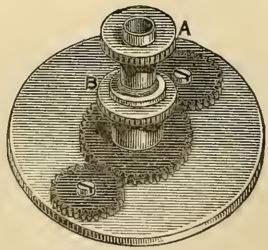
**Sidle's "Congress" Turntable.**—This turntable (so called from having been first exhibited at the "Congress of Microscopists" at Indianapolis) is shown in Figs. 228 and 229.

Fig. 228.



Into the upper surface of the rotating plate, and diametrically opposite and equidistant from the centre, are set two circular plates or disks, 1 inch in diameter, their surfaces flush with that of the large plate. Pivots from the two disks project through the plate, and each carries upon the lower side of the plate a toothed wheel. A hollow sleeve rotating freely upon the stem of the table carries a third and larger wheel, which gears into the two others and thereby gives rotation to the disks in the top of the plate. In Fig. 229 the turntable is inverted to show the mechanism.

Fig. 229.




Near the opposite edges of the two disks, the angular jaws which hold opposite corners of the slide are pivoted (as in Cox's and other forms), so that by giving rotation to the central wheel under the plate, the jaws may be made to approach or recede at pleasure.

A coiled steel spring, concealed within the hollow sleeve, serves to close the jaws, while a single motion of the milled head B, Fig. 229, upon the sleeve, opens them to their full extent; the lower milled edge A serves to give rotation to the turntable.

Although the jaws do not approach in a straight line, yet when properly adjusted, a line joining the pivots of the jaws will cut the

centre of the plate, whatever the position of the jaws, and they being always equidistant from the centre, it follows that the slide, when clasped between them, must be perfectly centered. For the purpose of retouching old slides the ordinary spring clips are retained.

An improvement has been made in the supporting stand, the iron tripod being now so arranged that the hind legs are removable and, being held in position by a clamp-screw, the same screw serves to clamp the instrument upon the edge of the work-table, should this mode of using it be preferred.

**New Process for Preparing the Brain.***—In place of nitric acid, chloride of zinc or chloral, a new process is described by which the brain is plunged in a saturated solution of bichromate of potass in a vessel large enough to admit of complete submersion, or if it be wanted for histological studies, susceptible of being cut in small slices for microscopical examination, bichromate of ammonia should be substituted for bichromate of potass. The brain should remain immersed a fortnight or longer; it will then be much swollen, and the infiltration will be completed. It is then taken out of the bath and plunged into simple water, in order to expel any excess of the bichromate. It is then placed in a bath of carbolic acid, 25 grammes to 1000 grammes. This process has the property of hardening the brain-substance, and reducing it almost to its normal size. A little acid must be added from time to time in order to keep up its hardening effect, which is apt to lessen. Six to ten days will suffice for its remaining in the acid bath.

As soon as the brain is taken out of the carbolic acid bath, it is plunged into a bath of pure glycerine for three or four days; the specimen may be wrapped in a cloth so as to prevent any part of the brain from emerging from the ambient liquid. It should not be left longer in the glycerine, for the brain absorbs a very large quantity of it, which might interfere with the hardening process. The brain is then taken out, placed on the flat side on soft linen, and exposed to the air. Should there be an excess of glycerine, plunge it for eight to ten minutes in a water bath. It is left now to itself, and will assume a green bronze colour, dry, and mummify almost insensibly. In two or three weeks the desiccative process will be completed. The specimens can be kept in open air or in boxes.

This process of preserving the brain, though seemingly complicated, is in reality very simple, if once the habit of using it be acquired. Such brains have now been in the laboratory for two years and a half, completely imputrescible, and have lost only three-tenths of their original value. They are susceptible of being freely sliced for histological investigation.

**Action of Concentrated Osmic Acid on Bone-cells.**†—M. F. Tourneux has studied the exact form and intimate relations of the osteoblast by the combined action of impregnation of the tissue with concentrated osmic acid, and decalcification by the aid of formic acid

* Lond. Med. Rec., Aug. 15, 1881, pp. 308–9.

† Bull. Sci. Dép. Nord, iv. (1881) pp. 113–15.

(2 to 3 per cent.); if the fragment of bone thus treated be only a few millimetres thick (rat, guinea-pig), twenty-four to forty-eight hours is sufficient to soften it; thicker pieces may require decalcification for a week. After washing, sections were then made, and these were mounted in glycerine. The osteoblasts are now seen as "true excavations" filled with liquid; fine prolongations become observable, and the primitive bone-cell is found to have been pushed to the wall of the osteoblast, owing to the development of a liquid between it and the osseous matter, and to have carried its prolongations into the neighbouring canaliculi. When a series of young forms are studied one can see spherical vacuoles developed in the interior of the osteoblast. The author explains that this appearance is not due to the production of a gas by the action of the formic acid, as it is seen when such reagents as picric or chromic acids are used instead.

**Mounting Chick Embryos whole.*** — Dr. C. S. Minot recommends the following method for embryos under forty hours. The egg is opened in the usual manner in warm 0·5 per cent. salt solution, the blastoderm freed from the yolk membrane, then swayed with pincers to and fro in the liquid to remove the superfluous yolk, and then floated out on a glass slide on which it is to remain permanently. It is next treated with several fluids, *all* of which should be dropped on the centre of the germ disk, so as to spread out the blastoderm evenly by their centrifugal flow. Wash off thoroughly with distilled water. Remove the water as fully as possible by bibulous paper, and allow the specimen to remain fully spread out until the edges are dried. The embryo will then escape distortion during the further treatment. Care must be taken that the embryonic area remains moist. Drop on two drops of a ½ per cent. osmic acid solution: leave standing for two or three minutes until a slight browning is produced, wash off again with distilled water, stain with picro-carmine, which dyes the blastoderm after a variable time, according to the intensity of the osmic acid action. The next step is important, because it stops the further darkening by the osmium, which otherwise injures or ruins the specimen. Pour Müller's fluid, or 0·5 per cent. chromic acid solution, on the slide, and leave it overnight. The next morning the blastoderm is ready for dehydration by alcohol, and mounting in the usual manner in balsam, or better, in three parts pure Canada balsam mixed with one part dammar varnish.

Embryos mounted in this way make very perfect preparations, surpassing, indeed, those otherwise treated.

**Mounting Echinoderm-larvæ.** — The following mode of preparing and mounting Echinoderm-larvæ has been communicated to Dr. Carpenter † by Mr. Percy Sladen who mounted the slides which attracted much attention on the Scientific Evening of 3rd December, 1879 (see Vol. III. (1880) p. 375). "For killing and preserving Echinoderm-zooids I have come to prefer either osmic acid or the

* Amer. Natural., xv. (1881) pp. 841-2.

† 'The Microscope and its Revelations,' 6th ed., 1881, pp. 646-7.

picro-sulphuric mixture of Kleinenberg of one-third strength. The latter, of course, destroys all calcareous structures; but the soft parts are preserved in a wonderful manner. If the diluted Kleinenberg's mixture is used, let the zooids remain in it for one or two hours; then wash them thoroughly in 70 per cent. spirit, until all trace of acid is removed; then strain; then again wash in 70 per cent. spirit, transfer them to 90 per cent. spirit for some hours, and lastly to absolute alcohol; transfer them from this to oil of cloves; and finally, mount in Canada balsam in the usual manner. If osmic acid be used, place three or four of the living zooids in a watch-glass of sea-water, and add a drop of the 1 per cent. solution. They should not remain even in this weak solution for more than a minute, and should then be thoroughly washed in a superabundance of 35 per cent. spirit, to prevent the deposit of crystals of salt consequent on the action of the osmic acid; then transfer the specimens to 70 per cent. spirit, and proceed as in the other case."

**Mounting Class.**—The Manchester Microscopical Society have adopted the excellent idea of establishing a class for affording beginners instruction in dissecting and mounting of objects, the work being superintended and practically illustrated by several of the more experienced members.*

**Mode of detecting Adulterations in Flour by the Microscope.**†—A. Cattaneo publishes two tables, with illustrative text, giving a detailed account of the anatomical differences in meals and in wheat, and of the adulterations of wheatmeal with the meal of rye, barley, maize, rice, oat, and millet, the latter of which, however, rarely occur. Besides other cereals, the flour is also adulterated with that of leguminous plants, and others containing abundance of starch, as the potato, horse-chestnut, Spanish chestnut, lupin, vetch, pea, lentil, haricot, &c. A comparative description of the starch-grains of these various substances is given.

**Reagent for small Quantities of Oxygen from Living Organisms.**‡—T. W. Engelmann claims to have discovered a reagent by which the evolution of oxygen can be detected in any microscopic organism, as, for example, a single chlorophyll-grain; and, within certain limits, even the amount of oxygen evolved be determined. The sensitiveness of the reagent is so great that far less than the hundred-billionth part of a milligram can be detected with certainty. It acts also so quickly that sudden changes in the amount of oxygen given off are indicated momentarily without loss of time. The reagent is any of the ordinary bacteria of putrefaction, especially the smaller forms, *Bacterium termo*.

It is well known that these bacteria are, in their motile condition, dependent to an extraordinary degree on the presence of oxygen,

* See Report of closing meeting for the first year, North. Microscopist, i. (1881) p. 245.

† Rend. R. Ist. Lomb. Sci. e Lett. xiv. See Bot. Centralbl. vii. (1881) p. 173.

‡ Bot. Ztg., xxxix. (1881) pp. 441–8.

collecting in enormous quantities, and moving about with great rapidity wherever they come into contact with the air, and losing their motility the moment this is removed. Exposed to a stream of pure hydrogen they soon subside completely to rest; pure oxygen acts with greater energy than the atmospheric air.

If a drop of defibrinated blood, which has been oxygenated by shaking in the air, is run into a drop of water between two glasses in which all bacteria have come to rest, they begin at once again to move about actively at the point of contact of the two fluids. This does not take place (or at least only at a very few points, and for a very short time), if, instead of arterial blood, that is taken through which a stream of carbonic oxide has been passed immediately before. If, instead of the drop of oxygenated blood, green cells, such as *Euglena*, a piece of a filamentous alga, or a brown diatom like *Navicula*, are brought into contact with the drop containing motionless bacteria, and observed under a cover-glass with a magnifying power of 200–300, the bacteria are seen immediately to begin to swarm in great quantities about these cells, while in all other parts of the drop they are completely at rest. If the field of view is now suddenly darkened, but not so much as to prevent the bacteria from being still distinctly visible, the swarming bacteria at once come to rest, either remaining stationary at the same spot, or dispersing themselves through the fluid by molecular motion. When the light is again let in, the motion recommences.

The only satisfactory explanation of these phenomena is that the chlorophyllaceous cells give out oxygen under the influence of light, and that this is the cause of the movements of the bacteria, and of their collecting round the spot where it is given off.

The following are some of the results of the application of this test obtained by Engelmann.

All chlorophyllaceous cells of both lower and higher plants give off oxygen in the light, even when the ordinary green colour is replaced by brown, as in diatoms, or by olive-green or light green, as in many Flagellatæ and Oscillatorieæ. The same is the case with chlorophyllaceous animals, as *Paramecium bursaria*, *Hydra viridis*, and *Spongilla*, sometimes very energetically.

The parenchymatous cells of the leaf of seedlings of *Nasturtium* grown in the dark, which contain etiolin but no chlorophyll, when brought into moderately strong light, momentarily exhale oxygen. But after exposure to the light for an hour at a uniform temperature of 21° C., the yellow colour of the cells was not sensibly altered.

The energy of the evolution of oxygen in different kinds of cells is greater the larger the amount of chlorophyll, or of other colouring matter with the same physiological properties. It is, for example, very great in *Euglena viridis*, or in young cells of *Zygnema*; small in cells of *Spirogyra* where the chlorophyll-bands are narrow and some distance apart, and in the guard-cells of the stomata of the leaf of *Tradescantia*. No evolution of oxygen takes place from cells with colourless protoplasm, as monads, amœbæ, the mycelial filaments of moulds, the root-hairs of *Hydrocharis*, the colourless cells of the

parenchyma of albinotized maple-leaves, &c., or from any non-chlorophyllaceous animal cells. Cells with a coloured cell-sap, but no chlorophyll, as those of the hairs on the filaments of *Tradescantia virginica*, petals, &c., do not give off oxygen into the air.

In all living cells, the evolution of oxygen takes place only at those spots where the chlorophyll-grains lie; and this is the case even when the chlorophyll-bodies have retreated from the cell-wall. Completely isolated chlorophyll-bodies of not more than 5 $\mu$ diameter continue to give off oxygen, as may be plainly seen in *Hydra viridis* and in many plant cells. The evolution proceeds even when the surrounding protoplasm has been completely destroyed. Even when a part of the chlorophyll-body has been destroyed, the remaining portion continues to act; but, as soon as its structure has been completely destroyed, the power of giving off oxygen ceases. The evolution is independent of currents in the protoplasm. Electrical induction-currents, which caused contraction in *Euglena*, produced no change in the evolution of oxygen.

The phenomenon takes place at all periods of growth and of cell-division; the nucleus appears to have no influence upon it. It seems to be absolutely dependent directly on the influence of light. The ultra-red rays passed through a solution of iodine in bisulphide of carbon, were found to be completely inactive; while the red rays of a wave-length between 0·70 and 0·60 $\mu$ were very active; the orange and yellow still more so; the green rays were the weakest; the blue (below 0·50 $\mu$) often considerably stronger. There is no perceptible interval of time between the impact of the light and the commencement of the development of oxygen; and the latter appears to cease the moment the former is withdrawn.

**Micro-photography.***—At the Brieg meeting of the Swiss Natural History Society, Dr. Du Plessis exhibited some micro-photographs of Hydroids—negatives on glass for projection—at the same time lamenting that the numerous technical difficulties produced disappointments which discouraged naturalists, although micro-photographs were of extreme importance both on account of their faithfulness and their usefulness for class instruction. M. His, however, contended that the discouragement arose primarily from the fact that proper objects were not selected, all microscopical objects not being suitable for photographing. The most unfavourable objects were often first selected, and there was always a temptation to employ too high powers. Only those objects should be used which can be observed with low powers, and especially those which give stereoscopic images.

**Histology and Microscopy.**—Microscopists have for many years insisted that it is absolutely essential that histologists should be grounded in the theoretical principles applicable to the instrument with which they work, and, that if this is not done, not only will erroneous interpretations of structure be put forward, but many points of importance will be altogether missed.

* Verh. Schweiz. Naturf. Gesell., lxiii. (1881) pp. 39–41.

In England, this view has not been accepted in practice, and an histologist who attempted to determine the true structure of an object by experimental or theoretical optical considerations was a *rarissima avis* indeed.

A very curious illustration of the mistakes that must inevitably result from this neglect will be found in a paper which has recently appeared by Mr. J. B. Haycraft "Upon the Cause of the Striation of Voluntary Muscular Tissue," * in which the author, with much care and ingenuity, reproduces the twice reproduced view of Mr. Bowman, that the striation of muscular tissue is simply an optical effect caused by the undulating shape of the fibres.

The paper evidently commended itself to histologists of eminence, as it was printed at length in the 'Proceedings of the Royal Society,' and reprinted in the 'Quarterly Journal of Microscopical Science,' and so far microscopists may congratulate themselves upon the acceptance in principle of a point on which they have hitherto vainly endeavoured to make themselves heard; but the paper points a still further moral in regard to the importance of a knowledge of the theory of microscopical appearances, for the author (who describes his paper as an attempt to explain the structure of muscle "on simple laws of geometrical optics") was unaware that, as established by Professor Abbe, there is a limit beyond which the laws of geometrical optics have no application, and that it is useless to attempt to reason as to the appearances presented by an object which requires a power of 500 times from those presented by one which requires a power of only 50 times. The laws of refraction in particular, for instance, no longer holding good in the case of minute objects, and cylindrical threads entirely losing the characters of refracting bodies which are distinctly exhibited by similar objects of larger size.

Whilst, therefore, the author is worthy of every commendation for his adoption of a method hitherto too generally neglected, the basis on which he rests his conclusions is unsound in consequence of the error into which he fell at starting.

We subjoin some extracts from Mr. Haycraft's paper which will, we think, be of interest to microscopists:—

"We can account for all these cross markings in a way which involves no theory, and requires for its appreciation but a knowledge of most elementary geometrical optics. If a small fragment of muscle be teazed out in water, salt solution, or almost any other fluid, and examined in the ordinary way, with a power of 300 diameters or more, the important fact may be made out (which is the basis of all my future observations) that the borders of the fibres are not smooth, but undulate, presenting wavy margins.

"In the fresh, unstained preparation there is a halo around the edge of the fibre which masks the crenulated border, yet by carefully adjusting the mirror so as to obtain oblique light, or by searching for a fibre partly in the shade of another, this may always be made out; in the case of insects' muscle, this is, however, always easy to demonstrate, for the fibres are much coarser, indeed, the appearance has

* Proc. Roy. Soc., xxxi. (1881) pp. 360–79 (1 pl.).

been often figured in the works even of recent histologists. If the preparation be stained by any of the ordinary dyes, perhaps most readily by picro-carmine, the border is in all cases very distinct, and the regularly sinuous margin is unmistakable. Now, what is the significance of the wavy outline? It is, as will readily be understood, that the fibre is ampullated, the wavy outline being but the optical expression of such a figure. A muscular fibre is then not a smooth cylinder, but is like the turned leg of a chair, or like the transversely ribbed neck of a common water-bottle in shape. If the fibre be broken up into fibrillæ, which is very easy after maceration in alcohol, these are seen to have just the same characters, indeed, a small bundle of fibrils is most convenient for study. It may be well to remark, that the ultimate fibrillæ often show but little cross markings, and appear almost smooth; that is, however, only due to their small size; a good lens will bring out both points. . . .

"The transverse stripings of the fibre are related to and correspond with the inequalities of the surface. The little elevations at the borders correspond, of course, to the little ridges, which run round the fibre, while the dips at the borders are the optical expressions of little valleys running between them. In the ordinary position, the dark stripe marks the position of the ridge, and the light stripe lies in the little valleys.

"Then, again, Dobie's line (Krause's membrane), which is a faint dark band in the very centre of the bright stripe, runs along the bottom of the valleys, and Hensen's stripe in the centre of the dark band, lies on the exact summit of the ridges.

"This position of the stripes in a normal muscular fibre, is the invariable rule, and the idea at once suggested itself, may not the shape of the fibre itself cause the cross stripings?

"Any student of natural philosophy would at once affirm that a structureless fibre of such a shape must be cross striped, and a glance at the ribbed neck of the water-bottle on the table will elicit the same answer from any one.

"The question we must now determine is, are the appearances seen in the fibre just the same, in all their details, as would be produced by a piece of glass, or any other homogeneous transparent substance of the same shape?

"Before, however, entering into theoretical grounds, it may be as well to give a full description of what is actually to be seen, for this has not yet been stated.

"With a structure of complicated figure, such as the one we are considering, it is obvious that there is no one focus in which it may be described. There is one pretty definite focus for a single speck or thin film, but even when examining a simple cylinder, it is evident that when the borders of it are clear and distinct, the upper surface is slightly out of focus. We shall see, that in the case of the muscle, although there is one position of the lens when the parts are very distinctly seen, and in which they have mostly been described, yet that on slightly altering the focus, the appearance is changed. These changes we must carefully study.

"For this purpose we may select the large muscles of the thigh of a rabbit; stretch them ever so little upon a piece of wood, and place them for some days in 50 per cent. alcohol. A high power is required for their examination. I have been in the habit of using a $\frac{1}{24}$-inch of Gundlach, a very perfect lens; a $\frac{1}{10}$-inch will, however, do. A small bundle of fibrils should be selected in preference to a whole fibre for examination.

"On focussing, it becomes at once apparent that on varying the adjustment ever so little, you may bring into focus the tops of the ridges or the bottoms of the valleys which lie between them. Now this slight alteration is sufficient entirely to change the optical appearances.

"First raise the lens until the fibre be out of focus, and is only to be seen as a dim streak running across the field, then bring it down until its form and the cross markings are distinctly to be seen (the border is now not quite distinct, on a level with the horizontal axis of the fibre). In this position, alternating light and dark bands are made out, but no vestiges of Hensen's stripes or Dobie's lines. The dark band corresponds with the valley and the light one to the ridge, or crest. . . . If the lens be now lowered ever so little, the stripes are reversed, a most curious point, which was noticed by Bowman, but afterwards lost sight of. The dark band now corresponds with the ridge, and the bright band with the valley. This is the focussing in which it is usually described, and in this position Dobie's line and Hensen's stripe are to be seen, as a rule, in uncontracted fibres.

"Between these two positions of the lens there is generally a well-marked intermediate one. The crests and valleys are both bright, and equally so, although the slightest movement of the fine adjuster will make either one or the other the darker; on the slopes, as it were, there are, however, narrow shaded bands. The fibre is now quite clear and distinct, and the longitudinal fibrillation is now best made out—if it can be seen at all—and yet there is no sign of either Hensen's or Dobie's stripes. These being the observed appearances (and they may be verified without very much trouble), I shall calculate theoretically the appearances which a homogeneous fibre of such a shape should present when examined by transmitted light, so as to see whether our observed effects tally with what may be theoretically calculated.

"Parallel rays of light pass upward through the fibre, and in their course are altered in direction. The substance of the fibre being of higher refrangibility than the fluid in which it is mounted, the thicker parts which correspond to the ridges will act like converging lenses, causing the rays of light to come to a focus, diverging again. The thinner parts (the valleys) will, on the other hand, act as diverging lenses, causing the rays to spread out. Now it is evident that when the objective is arranged to focus those rays which have passed through the fibre and converge over the ridges, at that same position the rays above the valleys will be diverging. This will produce a difference in the appearance, for the converging rays will give a bright band, while the position of those rays which diverge will

appear darker. Alter the focus by screwing the lens up or down, and, provided the fibre can still be seen, this state of matters will be reversed; for after converging, the rays above the position of the ridges will now be diverging, while at the same time those over the valleys will be converging and will appear bright.

"The condition which is intermediate between the low and high focussed picture of the fibre, would be obtained by shifting the lens half-way between these two positions. Hensen's stripe is no doubt due to rays passing through the centre of the ridges suffering little refraction in their course, and thus causing a brightness. Dobie's line might, of course, be the reverse of this, no rays at this point coming to the eye of the observer; but we shall speak of this more hereafter, when we shall show that there is some reason for suspecting at this point a distinct structure.

"Although it is indispensable to account theoretically for these appearances, yet to most persons a simple demonstration will carry more conviction than any proof deduced from the laws of optics, however well they be understood. Instead of showing 'what should be,' we will study 'what is.'

"For this purpose we will imitate as nearly as possible the figure of a muscular fibre on a small scale, and it shall be made out of a substance of uniform consistence throughout. What appearances will it present on microscopic examination? I have proceeded in the following manner:—A glass rod is heated in a spirit lamp and plunged into a bottle of Canada balsam; it is then withdrawn, and a little drop of the balsam is allowed to fall on a glass slide, or a thread of it may be laid out on the surface of the glass. Before the drop or thread has solidified it is indented with the milled head of a fine screw, and examined with a power of from twenty to fifty diameters, when cross shadings are to be observed. These are seen, moreover, to correspond with the surface impressions, and not only so, but they are reversed on altering the focus. Hensen's stripe is generally very well seen. The most beautiful and convincing object to study in this connection is a scale of the *Lepisma*. These are sold as test objects with many Microscopes. They are oval in shape, transparent, and singly refractile throughout, and beautifully ribbed in their length, these ribbings or groovings being indeed so fine that a power of at least 500 diameters will be required to make out those points to be here described. You would think on looking at one of these scales that a piece of muscle was flattened out before you on the field: no rough balsam model, but a perfect illustration taken from the back of a tiny insect.

"The appearances it is needless to describe, for they are, almost to the minutest detail, those of a muscular fibre. The bright and dark stripe interchanging with every alteration of focus, Hensen's stripe and Dobie's line (Krause's membrane) are all to be seen. In the case of *Lepisma* scale the line of Dobie is in the centre of a bright band, which is broader than the dark band with Hensen's stripe. This is, of course, the other way in the case of the muscular fibre.

"We see, therefore, that a muscular fibre presents just those appearances which a transparent body of uniform texture and of similar shape would possess. However conclusive these proofs may have been, it is well to collect all evidence possible to show that these markings are nothing more than optical effects, to which end a very searching experiment was suggested to me by Professor Tait. It is evident that if these cross bands are seen when parallel, or nearly parallel, rays of light are passing through the fibre, by using converging or diverging rays the appearance will be altered, and it will be possible by careful adjustment of a lens to cause a total reversal of the striping. If a fibre be carefully focussed, and a strong bi-concave diverging lens be placed between the stage of the Microscope and the mirror, and carefully moved about with the fingers, it will be possible entirely to alter the fibre, causing a total reversal of the cross bands. On withdrawing the lens, of course the fibre resumes its normal appearance. I may mention that several lenses were tried before one was found which would in at all a satisfactory manner show this phenomenon; when successful the experiment is very striking.

"In opposition to my view is the one generally accepted, namely, that the cross stripings are produced by differences along the fibre of chemical composition and refrangibility.

"Now suppose that there were along the fibre two alternating structures, A and B. Let A represent the bright stripe, and B the dark stripe. If A has a higher or lower refractive index than B, it is evident that although they were immersed in any number of fluids of refrangibility varying from the lowest to the highest, yet A would always be distinguishable from B, and the striping would always be apparent. Then, again, by placing the fibres in fluids of indices near to that either of A or B, the more striking would be the contrast. If, however, the fibre were homogeneous throughout, the striping being merely due to the form, then if the fluid and the fibre have the same refractive index, all striping will disappear. On Professor Tait's suggestions, I tried a series of fluids formed by mixing, in various proportions, alcohol, whose refractive index is low, with oil of cassia, which is high. In this way I have prepared specimens showing almost no cross striæ, the fibre appearing uniform until after most careful examination. . . .

"The position that we have reached is this: a muscular fibre presents such cross markings, varying with shifting the lens up or down, as a filament of homogeneous structure and similar shape. I have shown this experimentally, and have illustrated it by simple experiments, which it is in the power of any one to test. This being the case, I have searched to find if there be reason to assert any want of uniformity along the fibre, using various methods of staining. This I have failed to do, and have shown that the views commonly held are to be explained simply by the shapes of the fibres. . . .

"A fibril is structureless throughout its entire length, except that, perhaps, there may be membranes, or lines of fission, or layers of cement at the positions of the lines of Dobie; this we leave an open question. In using the word 'structureless,' I must not be mis-

understood; structureless membranes and tissues are fast losing their place in histology, and once simple protoplasm is now most complex. What I infer is that the stripes do not mark the positions of alternating layers of different structure, the presence of which are ordinarily maintained."

[We do not, of course, intend to express any opinion as to the real nature of muscular striation, our object being to recall the fact that the appearances presented by muscular fibre are not phenomena of geometrical optics and cannot be explained, nor the problems to which they give rise settled, on "simple laws of geometrical optics," a fact which is readily tested by experiments which it is in the power of any one to make.

If a piece of muscular fibre, which shows the striation well, is observed with a narrow incident pencil of direct or oblique light, and the eye-piece removed, a row of diffraction spectra will be seen at the back of the objective. If all these are shut off by a suitable diaphragm as in the well-known experiment, all striation disappears, or if some only are admitted—in varying combinations—a great variety of entirely different appearances will be obtained from the same fibre.

Whether, therefore, the phenomena of striation are due to the internal structure of the fibre or not, they are not phenomena of geometrical optics, which can of course tell us nothing as to optical images which depend on the admission or non-admission of diffracted light.]

**Microscopy in 1830–1881.**—Amongst the multiplicity of subjects to be dealt with, microscopy could be accorded but a brief reference in the Presidential Address at the York Jubilee Meeting of the British Association, confined to the question of the visibility of atoms, Sir John Lubbock stating that "we cannot, it would seem at present, hope for any increase of our knowledge of atoms by any improvement in the Microscope. . . . Even . . . . if we could construct Microscopes far more powerful than any we now possess, they would not enable us to obtain by direct vision any idea of the ultimate molecules of matter; . . . there may be an almost infinite number of structural characters in organic tissues which we can at present foresee no mode of examining."

It will not now be many years before this Society will have to celebrate its Jubilee, when the progress made in the mechanical, and still more in the optical arrangements of the Microscope, during the fifty years of the Society's existence, will no doubt be enlarged upon either in the Presidential Address or otherwise.

**Obituary. M. Nachet, Sen., and Mr. C. A. Spencer.**—We have to record the death of M. C. S. Nachet, Sen., the founder of the eminent firm of French opticians, which took place at his residence in Paris on the 28th ultimo, in his eighty-third year. He was one of the earliest in France to devote himself to the construction of achromatic objectives for the Microscope. In 1834 he entered the house of Chevalier, and during six years his exertions contributed

largely to the reputation of that house for improvements in the manufacture of Microscopes. In 1840 M. Nachet commenced business as an optician on his own account, confining himself principally to the Microscope, and specialities required by surgeon-oculists. In 1842 he contributed a paper to the Académie des Sciences (tome xiv.) describing the construction of achromatic objectives in which curvatures of 0·5 mm. radius were employed. From that date he received the advice and encouragement of some of the leading scientific men of the Continent: Amici, Arago, Babinet, Regnault, Milne-Edwards, and later Drs. Lebert and Charles Robin entrusted him with the execution of numberless experimental devices. In 1843 he again appeared before the Académie des Sciences (*vide* tome xvii.) with improved high-power objectives, and his camera lucida for vertical Microscopes. In 1844 (*loc. cit.* tome xviii.) he exhibited a Microscope composed of a doublet with a concave ocular (since developed into the "Loupe de Brücke"). In 1845 (*loc. cit.* tome xx.) he produced improved high powers using a fourth achromatic combination. In 1846 (*loc. cit.* tome xxii.) he devised his erecting Microscope for dissecting, &c., which was described in Quekett's work. In 1847 (*loc. cit.* tome xxiv.) he brought out his well-known prism for oblique illumination to be used in combination with the mirror in the optic axis. At that date his son Alfred was admitted into partnership, and various forms of binoculars, &c., have since been devised by the firm, which are referred to in the popular text-books of the Microscope. For some years past M. Nachet, Sen., had taken no active part in the business. Those who knew him personally will remember his kindliness, and also the liberality with which he carried out the construction of experimental apparatus. His lifetime may be said to comprise the whole period of the development of the compound achromatic Microscope from the earliest doublets up to the latest homogeneous-immersion objectives.

We have also to record the death of a well-known eminent American optician Mr. Charles A. Spencer, which took place on September 28th at Geneva, N.Y., in his sixty-eighth year. Mr. Spencer commenced work as an optician immediately on finishing his studies at Hobart College. Upwards of thirty years ago he produced dry objectives having apertures of 170° and higher, one of which was specially commended by Dr. Robinson, of Dublin. Mr. Spencer's objectives were much appreciated by the principal microscopists in America, such as Professors Bailey, Henry, Bache, Pierce, H. L. Smith, and Drs. Woodward and Torrey. President Barnard, of Columbia College, N.Y., was mainly instrumental in inducing Mr. Spencer to send specimens of his objectives to the Paris Exhibition of 1878, where a gold medal was awarded for their excellence. Mr. Spencer leaves two sons who have been associated with him for some years in the production of microscope objectives. He was one of the earliest to produce immersion objectives having apertures exceeding the maximum of dry objectives of 180°.

# PROCEEDINGS OF THE SOCIETY.

Meeting of 12th October, 1881, at King's College, Strand, W.C., The President (Professor P. Martin Duncan, F.R.S.) in the Chair.

The Minutes of the meeting of 8th June last were read and confirmed, and were signed by the President.

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The List of Donations (exclusive of exchanges and reprints) received since the last meeting was submitted, and the thanks of the Society given to the donors.

| | From |
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| Bowman, F. H., D.Sc.—The Structure of the Cotton Fibre in its Relations to Technical Applications. 211 pp. (11 plates and 5 figs.) (8vo. Manchester, 1881) .. .. | *The Author.* |
| Carpenter, W. B., C.B., &c.—The Microscope and its Revelations. 6th ed. 882 pp. 26 pls. and 502 figs. (8vo. London, 1881) .. .. .. .. .. .. .. .. .. .. | *Ditto.* |
| Gibbes, H., M.D.—Practical Histology and Pathology. 107 pp. (8vo. London, 1880) .. .. .. .. .. .. .. | *Ditto.* |
| Hermann, Dr. L.—Handbuch der Physiologie. The 6 vols. at present published. (8vo. Leipzig, 1873–1881) .. .. | *Mr. Crisp.* |
| Micrographic Dictionary. 4th ed. Parts 1–3 .. .. .. .. | *Mr. Van Voorst.* |
| Ormerod, E. A.—A Manual of Injurious Insects. 323 pp. and figs. (8vo. London) .. .. .. .. .. .. .. .. | *The Publishers.* |
| "Concentric" Turntable .. .. .. .. .. .. .. .. .. .. | *Mr. H. P. Aylward.* |
| Photographs illustrative of the Appearance of the Specimens described in his Paper on "Pseudo-polypi of the Colon, as seen with the naked eye and under the Microscope" | *Dr. J. J. Woodward.* |

The President remarked upon the great beauty of the photographs.

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Mr. Crisp exhibited and described Cosson's Dissecting and Observing Microscope (see p. 807), Goltsch's Binocular Microscope, Lacaze-Duthiers' Large Porte-loupe (see p. 939), Nachet's Microscope for the examination of the Skin, &c., and a Microscope by Schmidt and Haensch of Berlin, with movable stages on a similar plan to those described at pp. 880–1 of Vol. III. Also some Micro-photographs of various objects by Mr. J. H. Jennings, of Sherwood Rise, Nottingham, taken with the eye-piece in place, so as to avoid the central, more or less marked, flare-spot found to exist when the objective alone was used, the definition, nevertheless, being unimpaired and the photographs sharp. Mr. Jennings, in a letter accompanying the photographs, calls attention to their value for illustrating scientific papers, &c. "The chief expense is the artist, but if the engraver can work from a good photograph by the carbon process or otherwise, the expense is considerably reduced. Lantern slides for lectures can also be easily prepared from the photo-micrograph negatives." Mr. Crisp also called attention to a slide of Foraminifera of exceptional excellence exhibited by Mr. F. H. Balkwill, of Dublin, containing fifty species on a photographed background with the name of each species.

**Mr. J. W. Stephenson** exhibited two slides of test diatoms (*Pleurosigma formosum*), the one mounted in balsam and the other in phosphorus, pointing out, in reply to a question, that where the refractive index of the medium was approximately the same as that of the object, the latter would be nearly invisible when mounted, its degree of visibility depending upon the difference between its refractive index and that of the medium. The refractive index of the silica of the diatom was about 1·43, that of the balsam 1·54, and of the phosphorus 2·1, so that the visibility of the diatoms in phosphorus, as compared with balsam, was as 67 to 11, or in other words the image was six times as strong.

Mr. Curties inquired what was the mode of mounting, and what preparation was required beforehand?

Mr. Stephenson said that the medium was a solution of phosphorus in bisulphide of carbon. Care was required owing to the extremely inflammable nature of the mixture; but so very small a quantity of bisulphide of carbon was used that the diatoms might be said to be mounted in nearly pure phosphorus.

Mr. Beck said that Möller had been making a series of experiments on mounting diatoms in these highly refractive substances, and he had found that, when phosphorus was used, the results were very remarkable.

Mr. Ingpen said he should like to hear from Mr. Stephenson what would be the difference in the appearance of an object when mounted in a medium of much greater refrangibility than itself as compared with one mounted in a medium of a much lower refractive index.

Mr. T. C. White inquired if Mr. Stephenson had employed phosphorus as a medium for mounting histological subjects? He thought the extension of its use to such objects would give very interesting results.

Mr. Stephenson said that, in addition to diatoms, the only objects he had so mounted were scales of *Lepisma*, *Podura*, and some others. The appearance presented by an object mounted in a medium of much higher refractive index than itself, as contrasted with the same object in a medium of lower index than itself, was in some cases very distinct—for instance, the test *Podura* scale, which gave the well-known "exclamation" markings in air, yielded little more than longitudinal striæ in phosphorus; the conditions were, in fact, reversed.

Mr. Crisp said that the difference in visibility between the two slides was even more strikingly brought out by looking at them with a low-power pocket-lens. While nothing could be seen but the outline in the case of the balsam objects, the markings of those in the phosphorus were clearly distinguished.

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**Mr. J. Mayall, jun.**, at the request of the President, explained the construction of the new form of diaphragm devised by Mr. Tighlmann, and adopted by Messrs. Queen and Co., of Philadelphia, for Beck's vertical illuminator, and made some further remarks which will be found at p. 941.

Mr. Crisp described, by means of a drawing on the board, Nachet's improved form of camera lucida with a gold film, which he believed had been seen for the first time in this country at the recent Sanitary Exhibition at South Kensington.

Mr. Ingpen said he had used one of the same kind for three or four years, with the exception that he had a silver film instead of a gold one.

---

Mr. Stewart described a curious appearance of luminosity observed studding the sides of the dark caves and tin-mines in the neighbourhood of Dartmoor. On examination he found it to emanate from a number of small cells filled with a pellucid cell-sap, and containing some small chlorophyll bodies. The appearance was that of the emission of a golden-green light, and was apparently produced by the cells reflecting white light, which assumed a greenish tinge from the colour of the chlorophyll bodies. The effect was probably due to a reflection similar to that of light from drops of dew. He believed that these cells were an immature form of moss.

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Mr. Crisp called attention to the explanation of Professor Abbe in regard to the use of two illuminating beams for binocular Microscopes with high powers, whereby advantage was taken of the large effects of parallax presented by wide-angled objectives, while, at the same time, the loss of focal depth attendant upon the wide angle was diminished by one-half (see p. 692).

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The President reminded the Fellows that at their last meeting he had called attention to some silicious spicules obtained from great depths, and had specially referred to some minute canals seen in them, and to some evidence which seemed to show that a minute cell-form had to do with the perforation and enlargement. He confessed to having felt some little doubt as to the derivation of the spicules, although, when things were given to him by a friend, he felt bound to accept the representations made about them. In this case, to make sure, he asked Mr. Moseley to let him have a small quantity of deep-sea soundings, taken during the 'Challenger' expedition, and he found there not only spicules with these canals, but also the green unicellular substance itself. In corresponding with Mr. Carter, he had obtained sufficient information to enable him to venture to write a short paper on the subject in the August number of 'Annals of Natural History.' He found also very clearly that the little penetrating tubules did not always reach the axial canal, but often ended in a bulb. Of course, this thing must have a name, and so the name *Spongiophagus* had been proposed for it, and he was very glad to find that Mr. Carter was investigating it. The great interest was as to the manner in which a growth of that kind could absorb the silica and seem to feed upon it; probably, however, its nutriment was derived from the remains of the organic portions of the sponge.

Mr. Crisp said that Mr. Carter had recently discovered in some fresh-water forms a *Spongiophaga* that had not previously been recognized (see p. 901).

**Mr. Crisp** said that at their first meeting after the Jubilee of the British Association at York a protest should be entered, not against the remarks of Sir John Lubbock, but against the provincial papers who had headed the paragraphs of the Presidential Address which related to the visibility of atoms with the title, "Stagnation of the Microscope." Before many years the Society would be celebrating its jubilee, and perhaps then their president would show how much had been done during the last fifty years to improve both the instrument and the objectives.

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**The President** announced that the Council had appointed a small committee to consider the subject of standard gauges for eye-pieces and substages, and they would be glad to hear any opinions from Fellows as to carrying it out. A great deal of attention had recently been drawn to the matter.

Mr. Beck, in reply to the President, said it might possibly be considered to be out of place for a manufacturer to give an opinion upon the subject, but he thought that the suggestion would be found difficult to carry out in practice, particularly if it was contemplated that all opticians should accept the same standards. It was beyond question that it was desirable that there should be a uniform gauge for object-glasses, so that those of various makers might be interchangeable; but when they came to eye-pieces, he thought that if the Society should say that he must make his eye-pieces the same size as Nachet's, for instance, he could not accept it, although, no doubt, Nachet had as good reasons for adopting his own pattern as English makers had for theirs. It must also be borne in mind that the length of the body was an important point with some makers, and so was the length of the substage, and the same apparatus would clearly be unsuitable for all Microscopes.

Mr. Crisp said he did not suppose it would be suggested that there should be only one gauge for eye-pieces.

Mr. T. Powell, in reply to a question, said that he quite concurred in the remarks of Mr. Beck.

Mr. Curties did not regard it as an impossible result to carry out the object for which the committee was appointed, but he should himself prefer that the matter be left where it was. A maker doubtless made his apparatus in the way best suited to his own Microscopes, and he could not be responsible for its performance when otherwise employed.

Mr. Groves said that, speaking as a worker, he thought that if the idea could be carried out, it would be a great comfort to himself and his fellow-workers, especially in the case of a class of students, where it would be of the greatest convenience to be able to apply various apparatus to the same Microscope.

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**Mr. Beck** said that he should very much like to see united action amongst the Fellows of the Society in regard to some special subject for general examination, and to have an evening set apart for its consideration, so as to see the different modes in which different persons

had approached the subject. He thought that in this way a practical bearing might be given to the work of the Society. Take, for instance, the subject of Bacteria; there was no consensus of observations upon it, and yet it was a subject which could so well be brought before the Society, and if it was put forth in the proper quarter, those who had already worked at it would no doubt be glad to meet together for conference. Take also the anatomy and life-history of particular classes of animals, say of the Arachnida or Entomostraca. It need not be one subject only, but two or three might be started at the same time. It was increasingly difficult, he knew, to get papers brought before the Society. There was a time when the other societies did not give attention to research made with the Microscope, and then a considerable number of papers were brought here, but now that they began to recognize the value of it, a paper which bore on the subject of geology was taken to the Geological Society, and the results of microscopical study in botany or zoology to the Royal Society or the Linnean Society.

The President said that he quite appreciated the remarks which had just been made by Mr. Beck. There was really no limit to the subjects which might be taken up with advantage.

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**The following Instruments, Objects, &c., were exhibited:—**

Mr. Aylward:—The Concentric Turntable (see p. 851).

Mr. F. H. Balkwill:—Slide of fifty species of Foraminifera, with name of each species on a photographed background.

Mr. Crisp:—(1–5) The five Microscopes above mentioned. (6) Apparatus for examining diffraction spectra (see p. 822). (7) Insect cage (see p. 526).

Mr. J. Mayall, jun.:—Tighlmann's Cylinder-Diaphragms for the Vertical Illuminator (see p. 941).

Dr. Millar:—An early Ross Microscope, and an upright Cabinet made at the same time, in which the rackwork is placed vertically so that the slides lie flat with their ends exposed on opening the door.

Mr. J. W. Stephenson:—Two slides of *Pleurosigma formosum* in balsam and phosphorus.

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**New Fellows**:—The following were elected *Ordinary* Fellows:—Messrs. Edmund Carr, M.A. (Camb.), F.M.S., John D. Hillis, M.D., F.R.C.S.I., John J. Pilley, Thomas S. Rowe, M.D., and Edward Ward.

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## Meeting of 9th November, 1881, at King's College, Strand, W.C.
J. W. Stephenson, Esq., Vice-President, in the Chair.

**The Minutes** of the meeting of 12th October last were read and confirmed, and were signed by the Chairman.

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**The List of Donations** (exclusive of exchanges and reprints)

received since the last meeting was submitted, and the thanks of the Society were given to the donors.

| | From |
|---|---|
| Van Heurck, Dr. H.—Synopsis des Diatomées de Belgique. Fasc. IV. Pseudo-Raphidées. 2e partie. Plates 53bis to 77. (Anvers, 1881) .. .. .. .. .. .. .. .. | *The Author.* |

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Mr. Crisp exhibited and described Holmgren's Apparatus for observing the circulation in the lung of a frog, a French Pocket Microscope (see p. 809), Salt's Pocket Microscope (see p. 936), and Watson's Nose-piece for Analyzer, Wenham Prism and Vertical Illuminator, and described Nachet's new Pocket Microscope (lent by Dr. Klein), and Crossley's Microscope with special arrangement for illuminating the swinging substage (see p. 653) (lent by Mr. Crossley).

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The Rev. J. J. Halley, of Melbourne, Vice-President of the Microscopical Society of Victoria, was introduced to the Meeting by the Chairman, and thanked the Fellows for the very cordial welcome which they had just given him as a representative of one of the youngest Microscopical Societies in the world. He had on leaving Australia been asked to thank the Royal Microscopical Society for the great kindness done to their local Society in affiliating it to the parent body. It was an act which he could assure them had been highly appreciated, and he trusted that they would be able to show that they were worthy of the honour.

Mr. Halley then referred to the microscopical work which was being done in the colony of Victoria, mentioning amongst others a mode of making wax cells for mounting objects. He said that, of course, there was nothing new in the idea of using wax for this purpose as it had been done over and over again, but as far as this particular method of making cells was concerned he believed it to be new, and it had at any rate the advantage of being simple, easy, and done in a very short time. A mixture of wax and spermaceti (about $\frac{1}{6}$th part of the latter) was placed hot upon the middle of the slide, and the surface having been made perfectly level by passing over it a gauge made of glass, the slide was placed upon the turntable and the cell was turned up out of the solid wax.* He had with him a number of specimens from which the Fellows could judge for themselves as to the extreme neatness of their appearance, and so far as durability went he thought they would be equal to anything hitherto devised; those which he exhibited had stood the severe test of travelling from Australia, knocking about in his portmanteau, and passing through the Red Sea in the month of August, which even to an Australian was no joke. Turning to work done in connection with the fauna and flora of the colony, it would easily be imagined that they had a wide field open to them, seeing that their shores were so remarkably rich, particularly in *Bryozoa*—a term which they had adopted in preference to *Polyzoa*. Their Secretary, Mr. Goldstein, was himself working out this subject.

* See this Journal, iii. (1880) p. 860.

Already they had determined no less than thirty new species and several genera. Work like this was favoured by the advantages they possessed of obtaining specimens in large lumps, sometimes as much as 3 or 4 feet through, instead of being dependent on the small and dried specimens which alone could be obtained in England. As in Australia they had prospered commercially, so he hoped they might also prosper in their scientific pursuits. They were very careful in everything connected with matters of education, amongst which those relating to science were by no means forgotten.

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**Mr. Crisp** called attention to a slide of *Surirella gemma* mounted in phosphorus by Mr. Stephenson, which illustrated the advantage of mounting in media of high refractive index in a more striking manner than had yet been seen, the diatom being resolved with the most remarkable and exceptional clearness.

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**Mr. B. W. Richardson's** paper on "Multiple Staining of Animal Tissues with Picro-carmine, Iodine, and Malachite-green Dyes, and of Vegetable Tissues with Atlas-scarlet, soluble Blue, Iodine, and Malachite-green Dyes" was read (see p. 868).

Mr. Stewart said it seemed to him extremely important that with such papers they should have specimens before them upon which they could form a judgment, as when any one discovered a new process he was very likely to become enamoured of it. He did not of course say this in any disparagement of the present paper, but he thought it would be very much better if, in future, papers of that kind could be illustrated by the exhibition of type specimens of what the particular reagents were capable of doing.

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**Mr. J. C. Sigsworth** said he had understood that the new catalogue of the books in the Society's library was nearly ready, but that it was not going to be printed; he should be glad to know if such was the case.

The Chairman said that the announcement was premature, the question of printing not having been yet decided by the Council. It was, however, under consideration.

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**Mr. J. Mayall, jun.**, exhibited an Abbe Apertometer, which was devised by Professor Abbe specially for the measurement of very large apertures. The original one was of crown glass, which had a somewhat low refractive index, and this necessitated the pointers being placed so far apart that it was sometimes a little difficult to see them. The improved form was made of flint glass with a refractive index of 1·631, and this enabled the pointers to be placed nearer together so that they could be seen with greater facility. The scale was marked up to 1·40, so that no doubt apertures could be measured up to 1·50.

Mr. Mayall also exhibited a specimen (lent by Mr. T. S. Bazley) of a new micrometer plate ruled in America by Fasoldt, who undertakes to rule lines of any given fineness up to $\frac{1}{1000000}$ of an inch, but he was obliged to say, after examining the plate before them, which was from 10,000 to 120,000 lines to the inch, that the lines

were so slightly ruled that their practical value was very small. The lines ruled by Nobert were very much more distinct, and, therefore, much better as scales.

Mr. Crisp said that with regard to the claim to have ruled 1,000,000 lines to the inch, the only suggestion of a proof was that the micrometer screw had been set to that degree of fineness, which, of course, was quite another matter (see p. 949).

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Mr. Dreyfus called attention to slides of *Syzygites megalocarpus* by Dr. Zimmermann, Professor of Botany at Chemnitz, who had acquired considerable reputation for mounting micro-fungi. These slides showed distinctly both zygospores and azygospores, proving that this spore is also formed without conjugation. He also exhibited slides of *Aspergillus glaucus*, *Pilobolus crystallinus*, and *Mucor racemosus*.

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Mr. Crisp said they had to regret the deaths of two gentlemen well known in the microscopical world. Mr. C. S. Nachet, the founder of the French firm of that name, had died on the 28th October at the advanced age of 83, and Mr. C. A. Spencer, of Geneva, U.S.A. (one of the early makers of objectives with apertures exceeding that of 180° dry objectives), had died on the 28th September.

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The Rev. Dr. L. G. Mills' paper on "Diatoms from Peruvian Guano" was read, and was illustrated by specimens exhibited under the Microscope and also by drawings (see p. 865).

The Chairman said he did not notice that the author had suggested any reason for the changes which he had observed to take place in the species of diatoms now found in this guano.

Mr. Michael said that the term "Peruvian Guano" was a very wide one, and he thought that as the first deposits of this substance were pretty well worked out, what came over here now was from another deposit altogether. He, therefore, inclined to think that this change in the varieties of the diatoms really indicated that the deposits now received were from a new locality, or it might even be that the old deposit was being worked at a much lower level than formerly. Moreover, although various guanos may correctly be called "Peruvian," still they might come from widely different districts.

Mr. Casaux said that his experience was that there were no two cargoes of guano alike, but that it came from various places, and its uniformity of quality could never be depended upon.

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Mr. T. Charters White said he had for many years past felt the need of some apparatus by which the development of the lower forms of animal life could be watched under the Microscope under similar conditions to those in which the objects naturally existed. A large number of growing slides had been brought before them, but he had never found that they were of very much use, certainly not so useful as one which was given to him a short time ago by a member of the Quekett Club, Mr. W. Goodwin. It was necessary in any contrivance of this kind to have the objects kept constantly wet, and to afford an opportunity of constantly observing them without the danger of their

being crushed, which would be sure to occur if the cover were shifted in the least degree. The contrivance to which he referred (see p. 946) consisted of a triangular piece of glass about 2 inches on the base; at a short distance from each angle a small block of vulcanite was cemented upon the glass and a small piece of thin glass was fitted between them so that it could not be shifted laterally; in the centre of the thin glass a hole was drilled, and a small metal ring was cemented round the hole. Under the thin glass some thin strips of blotting-paper were fixed, and if water was slowly dropped into the hole it was drawn off under the thin glass by means of the blotting-paper. The slide answered its purpose so well practically that he thought it was worth bringing before the notice of the Meeting.

Mr. Stewart thought it probable that minute organisms might get under the blotting-paper or entangled amongst its fibres.

Mr. Curties said that the thin disk of glass was held down in its place by small vulcanized rings fitting over the vulcanite blocks. He had found that these blocks were liable to get loose, so that it would probably be necessary to make them of glass.

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**Mr. Watson** exhibited and described a form of Stephenson's Safety Stage, which was more simple than any which had hitherto been made.

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**The Chairman** announced that the first Conversazione of the Session would be held on the 7th December, and expressed a hope that there would be a better exhibition of objects than on the previous occasion.

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**The following Objects, Apparatus, &c., were exhibited**:—

Mr. Bolton:—Vorticellæ and Acinetæ.

Mr. Crisp:—(1) French Pocket Microscope (see p. 809), (2) Salt's Pocket Microscope (see p. 936), (3) Sidle's "Acme" No. 4 Microscope (see p. 657), (4) Watson's Nose-piece for Analyzer, Wenham Prism and Vertical Illuminator, and (5) Holmgren's Apparatus for observing the circulation in the lung of a frog.

Mr. Crossley:—Microscope with special arrangement for illuminating the swinging substage (see p. 653).

Mr. Dreyfus:—Slides of Fungi by Dr. Zimmermann of Chemnitz.

Dr. Klein:—Nachet's New Pocket Microscope.

Mr. J. Mayall, jun.:—(1) Abbe's Apertometer of dense glass, (2) Fasoldt's Test-plate (see p. 949).

Rev. L. G. Mills:—Diatoms from Peruvian guano (see p. 865).

Mr. Stephenson:—*Surirella gemma* mounted in phosphorus.

Mr. Watson:—(1) Microscope of similar construction to that figured *ante*, p. 517, (2) New form of Stephenson's Safety Stage.

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**New Fellows**:—The following were elected *Ordinary* Fellows:—Messrs. Robert Bygott, Walter T. Christian, F. Howard Collins, George Healey, Charles Newton, Joseph B. Robinson, and Louis A. Sillem.

Walter W. Reeves,
*Assist.-Secretary.*

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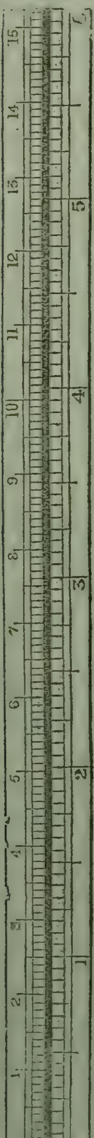
LONDON: PRINTED BY WILLIAM CLOWES AND SONS, LIMITED, STAMFORD STREET AND CHARING CROSS.

## I. Conversion of British and Metric Lineal Measures.

Scale showing the relation of Inches to Centimetres, &c.




1000 μ = 1 mm.
10 mm. = 1 cm.
10 cm. = 1 dm.
10 dm. = 1 metre.

*Inches, &c., into Micromillimetres, Millimetres, &c.*

| ins. | μ |
|---|---|
| 1/25000 | 1·015991 |
| 1/20000 | 1·269989 |
| 1/15000 | 1·693318 |
| 1/10000 | 2·539977 |
| 1/9000 | 2·822197 |
| 1/8000 | 3·174972 |
| 1/7000 | 3·628539 |
| 1/6000 | 4·233295 |
| 1/5000 | 5·079954 |
| 1/4000 | 6·349943 |
| 1/3000 | 8·466591 |
| 1/2000 | 12·699886 |
| 1/1000 | 25·399772 |
| | mm. |
| 1/900 | ·028222 |
| 1/800 | ·031750 |
| 1/700 | ·036285 |
| 1/600 | ·042333 |
| 1/500 | ·050800 |
| 1/450 | ·056444 |
| 1/400 | ·063499 |
| 1/350 | ·072571 |
| 1/300 | ·084666 |
| 1/250 | ·101599 |
| 1/200 | ·126999 |
| 1/150 | ·169332 |
| 1/100 | ·253998 |
| 1/50 | ·507995 |
| 1/25 | 1·015991 |
| 1/20 | 1·269989 |
| 1/16 | 1·587486 |
| 1/15 | 1·693318 |
| 1/12 | 2·116648 |
| 1/10 | 2·539977 |
| 1/8 | 3·174972 |
| 1/6 | 4·233295 |
| 3/16 | 4·762457 |
| 1/5 | 5·079954 |
| 1/4 | 6·349943 |
| 5/16 | 7·937429 |
| 3/8 | 9·524915 |
| 7/16 | 11·112400 |
| 1/2 | 12·699886 |
| 9/16 | 14·287372 |
| 5/8 | 15·874858 |
| 11/16 | 17·462343 |
| 3/4 | 19·049829 |
| 13/16 | 20·637315 |
| 7/8 | 22·224801 |
| 15/16 | 23·812286 |
| 1 | 25·399772 |
| 2 | 50·799544 |
| 3 | 76·199316 |
| 4 | 101·599088 |
| 5 | 126·998861 |
| 6 | 152·398633 |
| 7 | 177·798405 |
| 8 | 203·198177 |
| 9 | 228·597949 |
| 10 | 253·997721 |
| 11 | 279·397493 |
| 1 ft. | 304·797265 |
| | metres. |
| = | ·304797 |
| 1 yd. = | ·914392 |

*Micromillimetres, Millimetres, &c., into Inches, &c.*

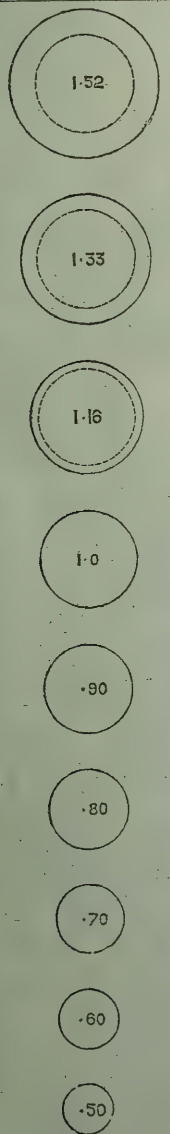
| μ | ins. | mm. | ins. | mm. | ins. |
|---|---|---|---|---|---|
| 1 | ·000039 | 1 | ·039370 | 51 | 2·00789 |
| 2 | ·000079 | 2 | ·078741 | 52 | 2·04726 |
| 3 | ·000118 | 3 | ·118111 | 53 | 2·08663 |
| 4 | ·000157 | 4 | ·157482 | 54 | 2·12600 |
| 5 | ·000197 | 5 | ·196852 | 55 | 2·16537 |
| 6 | ·000236 | 6 | ·236223 | 56 | 2·20474 |
| 7 | ·000276 | 7 | ·275593 | 57 | 2·24411 |
| 8 | ·000315 | 8 | ·314963 | 58 | 2·28348 |
| 9 | ·000354 | 9 | ·354334 | 59 | 2·32285 |
| 10 | ·000394 | 10 (1 cm.) | ·393704 | 60 (6 cm.) | 2·36222 |
| 11 | ·000433 | 11 | ·433075 | 61 | 2·40159 |
| 12 | ·000472 | 12 | ·472445 | 62 | 2·44096 |
| 13 | ·000512 | 13 | ·511816 | 63 | 2·48033 |
| 14 | ·000551 | 14 | ·551186 | 64 | 2·51970 |
| 15 | ·000591 | 15 | ·590556 | 65 | 2·55907 |
| 16 | ·000630 | 16 | ·629927 | 66 | 2·59844 |
| 17 | ·000669 | 17 | ·669297 | 67 | 2·63781 |
| 18 | ·000709 | 18 | ·708668 | 68 | 2·67718 |
| 19 | ·000748 | 19 | ·748038 | 69 | 2·71656 |
| 20 | ·000787 | 20 (2 cm.) | ·787409 | 70 (7 cm.) | 2·75593 |
| 21 | ·000827 | 21 | ·826779 | 71 | 2·79530 |
| 22 | ·000866 | 22 | ·866150 | 72 | 2·83467 |
| 23 | ·000906 | 23 | ·905520 | 73 | 2·87404 |
| 24 | ·000945 | 24 | ·944890 | 74 | 2·91341 |
| 25 | ·000984 | 25 | ·984261 | 75 | 2·95278 |
| 26 | ·001024 | 26 | 1·023631 | 76 | 2·99215 |
| 27 | ·001063 | 27 | 1·063002 | 77 | 3·03152 |
| 28 | ·001102 | 28 | 1·102372 | 78 | 3·07089 |
| 29 | ·001142 | 29 | 1·141743 | 79 | 3·11026 |
| 30 | ·001181 | 30 (3 cm.) | 1·181113 | 80 (8 cm.) | 3·14963 |
| 31 | ·001220 | 31 | 1·220483 | 81 | 3·18900 |
| 32 | ·001260 | 32 | 1·259854 | 82 | 3·22837 |
| 33 | ·001299 | 33 | 1·299224 | 83 | 3·26774 |
| 34 | ·001339 | 34 | 1·338595 | 84 | 3·30711 |
| 35 | ·001378 | 35 | 1·377965 | 85 | 3·34648 |
| 36 | ·001417 | 36 | 1·417336 | 86 | 3·38585 |
| 37 | ·001457 | 37 | 1·456706 | 87 | 3·42522 |
| 38 | ·001496 | 38 | 1·496076 | 88 | 3·46459 |
| 39 | ·001535 | 39 | 1·535447 | 89 | 3·50396 |
| 40 | ·001575 | 40 (4 cm.) | 1·574817 | 90 (9 cm.) | 3·54333 |
| 41 | ·001614 | 41 | 1·614188 | 91 | 3·58270 |
| 42 | ·001654 | 42 | 1·653558 | 92 | 3·62208 |
| 43 | ·001693 | 43 | 1·692929 | 93 | 3·66145 |
| 44 | ·001732 | 44 | 1·732299 | 94 | 3·70082 |
| 45 | ·001772 | 45 | 1·771669 | 95 | 3·74019 |
| 46 | ·001811 | 46 | 1·811040 | 96 | 3·77956 |
| 47 | ·001850 | 47 | 1·850410 | 97 | 3·81893 |
| 48 | ·001890 | 48 | 1·889781 | 98 | 3·85830 |
| 49 | ·001929 | 49 | 1·929151 | 99 | 3·89767 |
| 50 | ·001969 | 50 (5 cm.) | 1·968522 | 100 (10 cm. = 1 decim.) | |
| 60 | ·002362 | | | | |
| 70 | ·002756 | | | | |
| 80 | ·003150 | | | | |
| 90 | ·003543 | | | | |
| 100 | ·003937 | | | | |
| 200 | ·007874 | | | | |
| 300 | ·011811 | | | | |
| 400 | ·015748 | | | | |
| 500 | ·019685 | | | | |
| 600 | ·023622 | | | | |
| 700 | ·027559 | | | | |
| 800 | ·031496 | | | | |
| 900 | ·035433 | | | | |
| 1000 (= 1 mm.) | | | | | |

| decim. | ins. |
|---|---|
| 1 | 3·937043 |
| 2 | 7·874086 |
| 3 | 11·811130 |
| 4 | 15·748173 |
| 5 | 19·685216 |
| 6 | 23·622259 |
| 7 | 27·559302 |
| 8 | 31·496346 |
| 9 | 35·433389 |
| 10 (1 metre) | 39·370432 |
| | = 3·280869 ft. |
| | = 1·093623 yds. |

## II. NUMERICAL APERTURE TABLE.

The "APERTURE" of an optical instrument indicates its greater or less capacity for receiving rays from the object and transmitting them to the image, and the aperture of a Microscope objective is therefore determined by the ratio between its focal length and the diameter of the emergent pencil at the plane of its emergence—that is, the utilized diameter of a single-lens objective or of the back lens of a compound objective.

This ratio is expressed for all media and in all cases by $n \sin u$, $n$ being the refractive index of the medium and $u$ the semi-angle of aperture. The value of $n \sin u$ for any particular case is the "*numerical aperture*" of the objective.

| Diameters of the Back Lenses of various Dry and Immersion Objectives of the same Power ($\frac{1}{4}$ in.) from 0·50 to 1·52 N. A. | Numerical Aperture. ($n \sin u = a$.) | Angle of Aperture ($= 2u$). | | | Illuminating Power. ($a^2$.) | Theoretical Resolving Power, in Lines to an Inch. ($\lambda = 0{\cdot}5269\ \mu$ = line E.) | Penetrating Power. $\left(\frac{1}{a}\right)$ |
|---|---|---|---|---|---|---|---|
| | | *Dry* Objectives. ($n = 1$.) | *Water-Immersion* Objectives. ($n = 1{\cdot}33$.) | *Homogeneous Immersion* Objectives. ($n = 1{\cdot}52$.) | | | |
|   | 1·52 | .. | .. | 180° 0′ | 2·310 | 146,528 | ·658 |
| | 1·50 | .. | .. | 161° 23′ | 2·250 | 144,600 | ·667 |
| | 1·48 | .. | .. | 153° 39′ | 2·190 | 142,672 | ·676 |
| | 1·46 | .. | .. | 147° 42′ | 2·132 | 140,744 | ·685 |
| | 1·44 | .. | .. | 142° 40′ | 2·074 | 138,816 | ·694 |
| | 1·42 | .. | .. | 138° 12′ | 2·016 | 136,888 | ·704 |
| | 1·40 | .. | .. | 134° 10′ | 1·960 | 134,960 | ·714 |
| | 1·38 | .. | .. | 130° 26′ | 1·904 | 133,032 | ·725 |
| | 1·36 | .. | .. | 126° 57′ | 1·850 | 131,104 | ·735 |
| | 1·34 | .. | .. | 123° 40′ | 1·796 | 129,176 | ·746 |
| | 1·33 | .. | 180° 0′ | 122° 6′ | 1·770 | 128,212 | ·752 |
| | 1·32 | .. | 165° 56′ | 120° 33′ | 1·742 | 127,248 | ·758 |
| | 1·30 | .. | 155° 38′ | 117° 34′ | 1·690 | 125,320 | ·769 |
| | 1·28 | .. | 148° 28′ | 114° 44′ | 1·638 | 123,392 | ·781 |
| | 1·26 | .. | 142° 39′ | 111° 59′ | 1·588 | 121,464 | ·794 |
| | 1·24 | .. | 137° 36′ | 109° 20′ | 1·538 | 119,536 | ·806 |
| | 1·22 | .. | 133° 4′ | 106° 45′ | 1·488 | 117,608 | ·820 |
| | 1·20 | .. | 128° 55′ | 104° 15′ | 1·440 | 115,680 | ·833 |
| | 1·18 | .. | 125° 3′ | 101° 50′ | 1·392 | 113,752 | ·847 |
| | 1·16 | .. | 121° 26′ | 99° 29′ | 1·346 | 111,824 | ·862 |
| | 1·14 | .. | 118° 00′ | 97° 11′ | 1·300 | 109,896 | ·877 |
| | 1·12 | .. | 114° 44′ | 94° 56′ | 1·254 | 107,968 | ·893 |
| | 1·10 | .. | 111° 36′ | 92° 43′ | 1·210 | 106,040 | ·909 |
| | 1·08 | .. | 108° 36′ | 90° 33′ | 1·166 | 104,112 | ·926 |
| | 1·06 | .. | 105° 42′ | 88° 26′ | 1·124 | 102,184 | ·943 |
| | 1·04 | .. | 102° 53′ | 86° 21′ | 1·082 | 100,256 | ·962 |
| | 1·02 | .. | 100° 10′ | 84° 18′ | 1·040 | 98,328 | ·980 |
| | 1·00 | 180° 0′ | 97° 31′ | 82° 17′ | 1·000 | 96,400 | 1·000 |
| | 0·98 | 157° 2′ | 94° 56′ | 80° 17′ | ·960 | 94,472 | 1·020 |
| | 0·96 | 147° 29′ | 92° 24′ | 78° 20′ | ·922 | 92,544 | 1·042 |
| | 0·94 | 140° 6′ | 89° 56′ | 76° 24′ | ·884 | 90,616 | 1·064 |
| | 0·92 | 133° 51′ | 87° 32′ | 74° 30′ | ·846 | 88,688 | 1·087 |
| | 0·90 | 128° 19′ | 85° 10′ | 72° 36′ | ·810 | 86,760 | 1·111 |
| | 0·88 | 123° 17′ | 82° 51′ | 70° 44′ | ·774 | 84,832 | 1·136 |
| | 0·86 | 118° 38′ | 80° 34′ | 68° 54′ | ·740 | 82,904 | 1·163 |
| | 0·84 | 114° 17′ | 78° 20′ | 67° 6′ | ·706 | 80,976 | 1·190 |
| | 0·82 | 110° 10′ | 76° 8′ | 65° 18′ | ·672 | 79,048 | 1·220 |
| | 0·80 | 106° 16′ | 73° 58′ | 63° 31′ | ·640 | 77,120 | 1·250 |
| | 0·78 | 102° 31′ | 71° 49′ | 61° 45′ | ·608 | 75,192 | 1·282 |
| | 0·76 | 98° 56′ | 69° 42′ | 60° 0′ | ·578 | 73,264 | 1·316 |
| | 0·74 | 95° 28′ | 67° 36′ | 58° 16′ | ·548 | 71,336 | 1·351 |
| | 0·72 | 92° 6′ | 65° 32′ | 56° 32′ | ·518 | 69,408 | 1·389 |
| | 0·70 | 88° 51′ | 63° 31′ | 54° 50′ | ·490 | 67,480 | 1·429 |
| | 0·68 | 85° 41′ | 61° 30′ | 53° 9′ | ·462 | 65,552 | 1·471 |
| | 0·66 | 82° 36′ | 59° 30′ | 51° 28′ | ·436 | 63,624 | 1·515 |
| | 0·64 | 79° 35′ | 57° 31′ | 49° 48′ | ·410 | 61,696 | 1·562 |
| | 0·62 | 76° 38′ | 55° 34′ | 48° 9′ | ·384 | 59,768 | 1·613 |
| | 0·60 | 73° 44′ | 53° 38′ | 46° 30′ | ·360 | 57,840 | 1·667 |
| | 0·58 | 70° 54′ | 51° 42′ | 44° 51′ | ·336 | 55,912 | 1·724 |
| | 0·56 | 68° 6′ | 49° 48′ | 43° 14′ | ·314 | 53,984 | 1·786 |
| | 0·54 | 65° 22′ | 47° 54′ | 41° 37′ | ·292 | 52,056 | 1·852 |
| | 0·52 | 62° 40′ | 46° 2′ | 40° 0′ | ·270 | 50,128 | 1·923 |
| | 0·50 | 60° 0′ | 44° 10′ | 38° 24′ | ·250 | 48,200 | 2·000 |

EXAMPLE.—The apertures of four objectives, two of which are dry, one water-immersion, and one oil-immersion, would be compared on the *angular* aperture view as follows:—106° (air), 157° (air), 142° (water), 130° (oil).
Their actual apertures are, however, as ·80 ·98 1·26 1·38 or their numerical apertures.

THE

# ROYAL MICROSCOPICAL SOCIETY.

(Founded in 1839. Incorporated by Royal Charter in 1866.)

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**The Society** was established for the communication and discussion of observations and discoveries (1) tending to improvements in the construction and mode of application of the Microscope, or (2) relating to Biological or other subjects of Microscopical Research.

It consists of Ordinary, Honorary, and Ex-officio Fellows.

**Ordinary Fellows** are elected on a Certificate of Recommendation signed by three Fellows, stating the names, residence, description, &c., of the Candidate, of whom one of the proposers must have personal knowledge. The Certificate is read at a Monthly Meeting, and the Candidate balloted for at the succeeding Meeting.

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**The Meetings** are held on the second Wednesday in each month, from October to June, in the Society's Library at King's College, Strand, W.C. (commencing at 8 P.M.). Visitors are admitted by the introduction of Fellows.

In each Session two additional evenings are devoted to the exhibition of Instruments, Apparatus, and Objects of novelty or interest relating to the Microscope or the subjects of Microscopical Research.

**The Journal**, containing the Transactions and Proceedings of the Society, with a Summary of Current Researches relating to Zoology and Botany (principally Invertebrata and Cryptogamia), Microscopy, &c., is published bi-monthly, and is forwarded *gratis* to all Ordinary and Ex-officio Fellows residing in countries within the Postal Union.

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